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#241 JUNE 2025

Sky at Night

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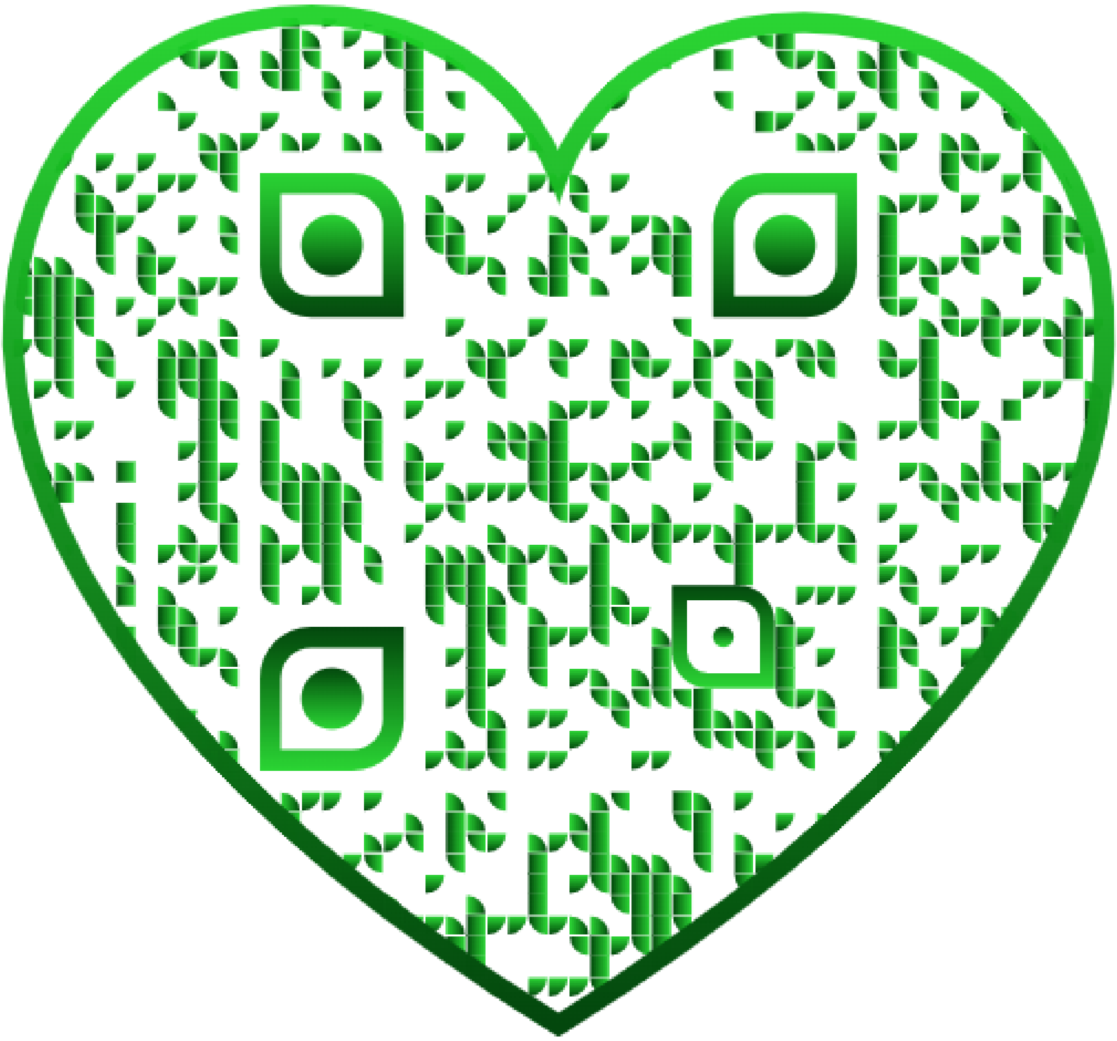

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Welcome

The ancient astronomers of Stonehenge keep us guessing

If you've been keeping track of where the Moon rises and sets on the horizon this year, you may have noticed something strange: its northern- and southernmost positions are as far apart as they can get. That's because we're currently in a two-year period known as a major lunar standstill, or lunistice – a similar concept to the Sun's solstices, if you thought those two words sounded similar.

You'd be forgiven for not noticing – it's difficult with so many built-up horizons – but 5,000 years ago, on the open plateau of Salisbury Plain, it would have been much more obvious to the builders of Stonehenge. Indeed, it's even thought that the changing positions of the Moon's path could have played a major role in the design of the iconic stone circle. All through this lunistice, researchers have been at Stonehenge, monitoring the stones' alignment with the Moon at key dates. Now, with their investigation nearing completion, English Heritage archaeologist Jennifer Wexler picks up the fascinating story for us on **page 34**.

This month, there's a great chance to see the impact of the major lunar standstill on the appearance of the Moon. On the night of 11–12 June, the full Moon's path from rising to setting will be close to as far south as it can possibly get, and so will be very low to the horizon. It's the perfect time to see the Moon illusion, which makes the Moon look far bigger than it really is. Turn to **page 76** for more about this quirk of human perception and how you can record it for yourself.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Tuesday 17 June.

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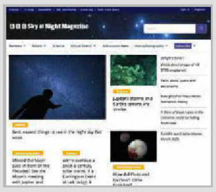
Sky at Night – lots of ways to enjoy the night sky...

Television

Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18



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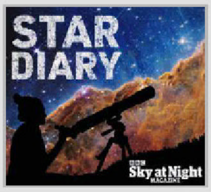

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Discover the best things to see in the night sky every week by listening to our Star Diary podcast

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The Sky Guide

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New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**

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This month's contributors

Hayley Smith

Science educator

"We don't talk about space weather as often as terrestrial weather, but its impact on space missions can be catastrophic." **Hayley looks at solar storms and how the Hayabusa mission (only just) survived, page 28**

Jennifer Wexler

Archaeologist

"Stonehenge is the ultimate observatory. People have been coming here to watch the skies for thousands of years, but the role of the Moon still remains a mystery to discover." **Uncover the stones' lunar links on page 34**

Alastair Gunn

Radio astronomer

"In space, not everything is as it seems. Myths abound, surrounding everything from planets and stars to black holes, gravity and even time itself." **Alastair debunks the biggest offenders on page 66**

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JUNE HIGHLIGHTS

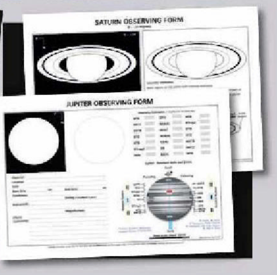
Interview: Earth, aliens and astronomy

Astrobiologist Penny Boston reveals what life on Earth can tell us about extraterrestrial life among the stars.

Sky at Night
The Messier catalogue

Messier Catalogue on your phone or tablet

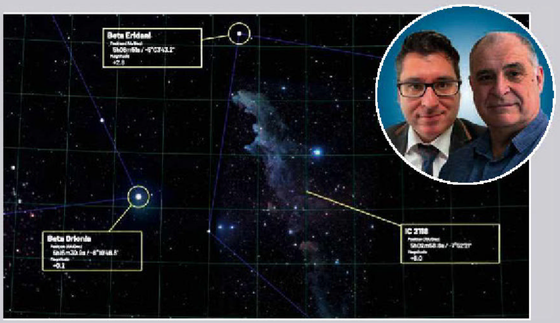
Download Messier's deep-sky catalogue for easy reference at your scope. How many can you tick off the list?



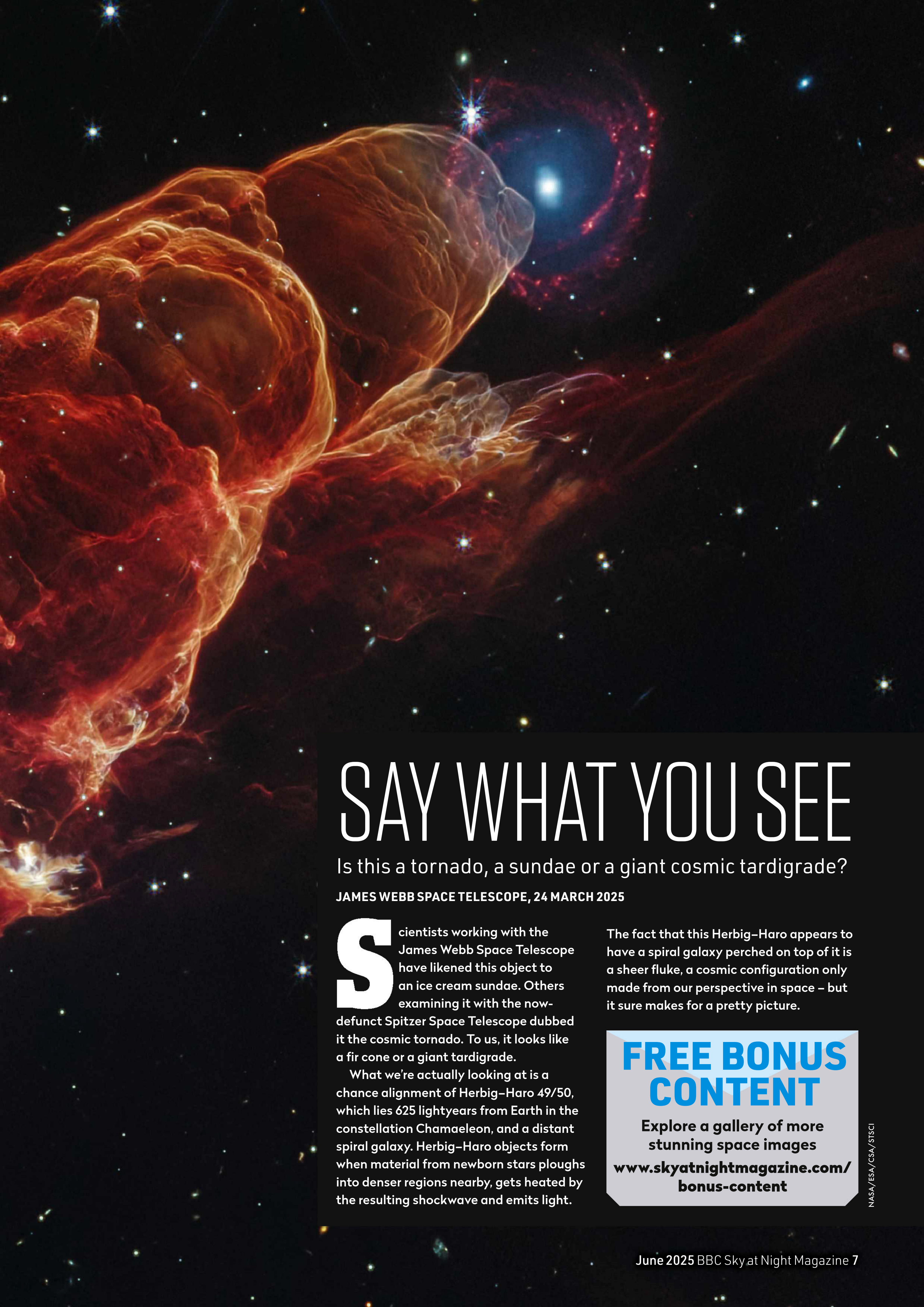
Planet and solar observing forms

Become a citizen scientist and keep records of your observations of the Sun and the planets.

The Virtual Planetarium



Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.



NASA/ESA/CSA/STSCI

SAY WHAT YOU SEE

Is this a tornado, a sundae or a giant cosmic tardigrade?

JAMES WEBB SPACE TELESCOPE, 24 MARCH 2025

Scientists working with the James Webb Space Telescope have likened this object to an ice cream sundae. Others examining it with the now-defunct Spitzer Space Telescope dubbed it the cosmic tornado. To us, it looks like a fir cone or a giant tardigrade.

What we're actually looking at is a chance alignment of Herbig–Haro 49/50, which lies 625 lightyears from Earth in the constellation Chamaeleon, and a distant spiral galaxy. Herbig–Haro objects form when material from newborn stars ploughs into denser regions nearby, gets heated by the resulting shockwave and emits light. The fact that this Herbig–Haro appears to have a spiral galaxy perched on top of it is a sheer fluke, a cosmic configuration only made from our perspective in space – but it sure makes for a pretty picture.

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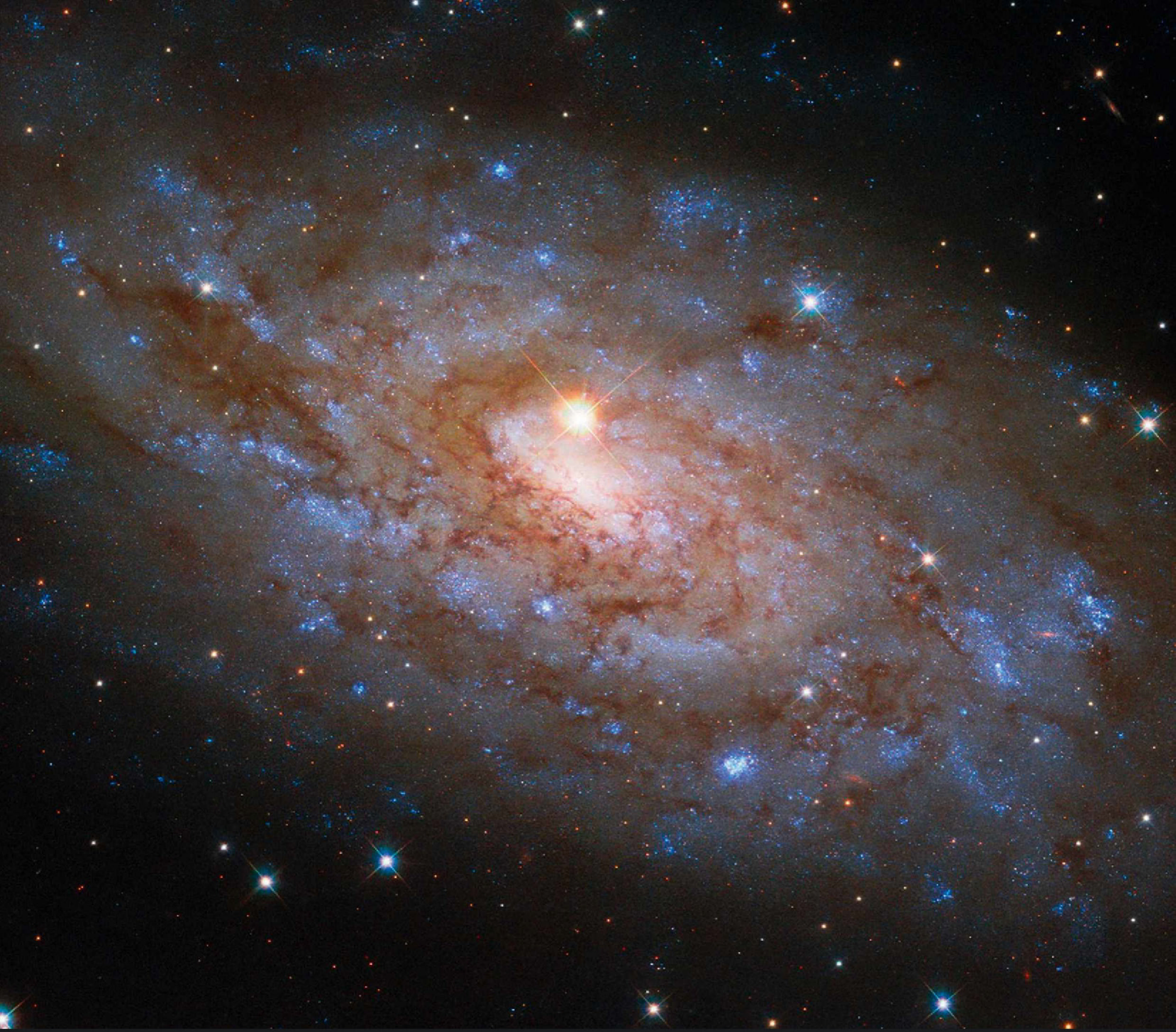
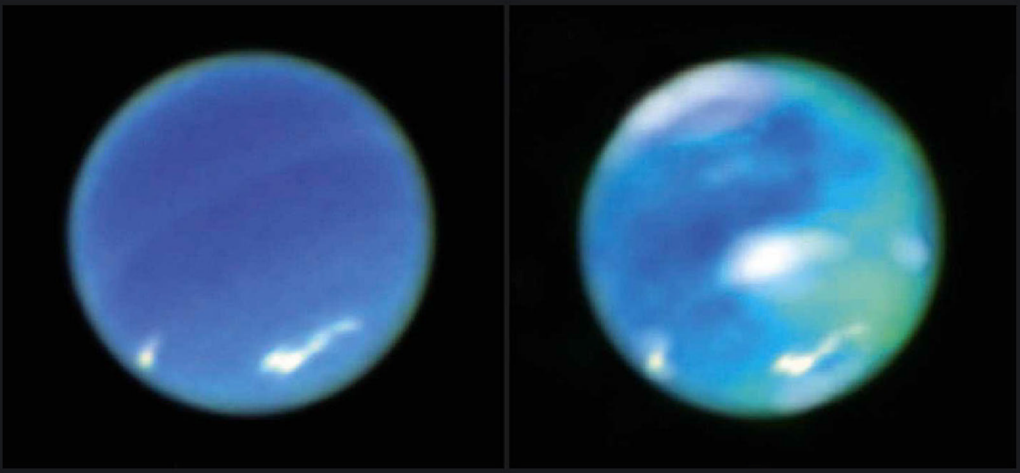


△ Stellar interloper

HUBBLE SPACE TELESCOPE, 24 MARCH 2025

NGC 5530 is a spiral galaxy 40 million lightyears away in the constellation of Lupus. That point of light isn't, as you might expect, a bright core powered by a central supermassive black hole, though. It's a closer Milky Way star a mere 10,000 lightyears from Earth that just happens to align with NGC 5530 in Earth's night sky.



△ Neptunian lights

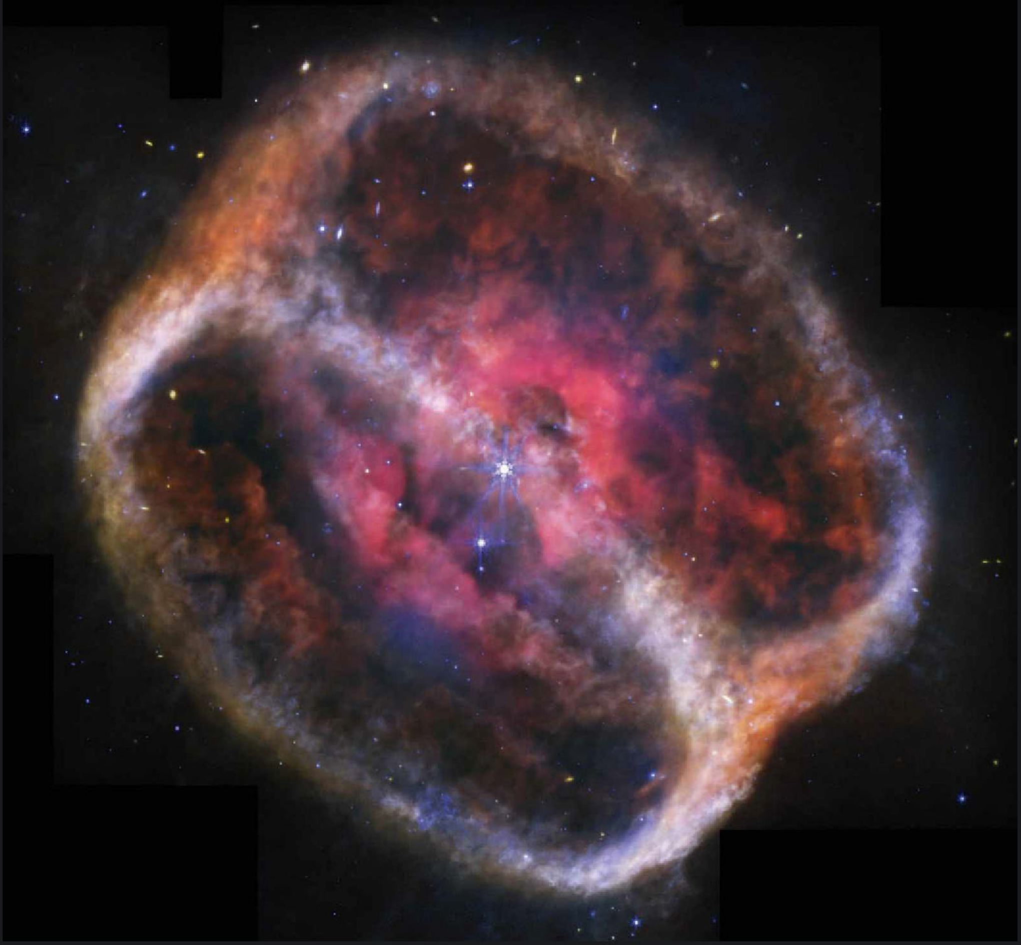
HUBBLE SPACE TELESCOPE, JAMES WEBB SPACE TELESCOPE, 26 MARCH 2025

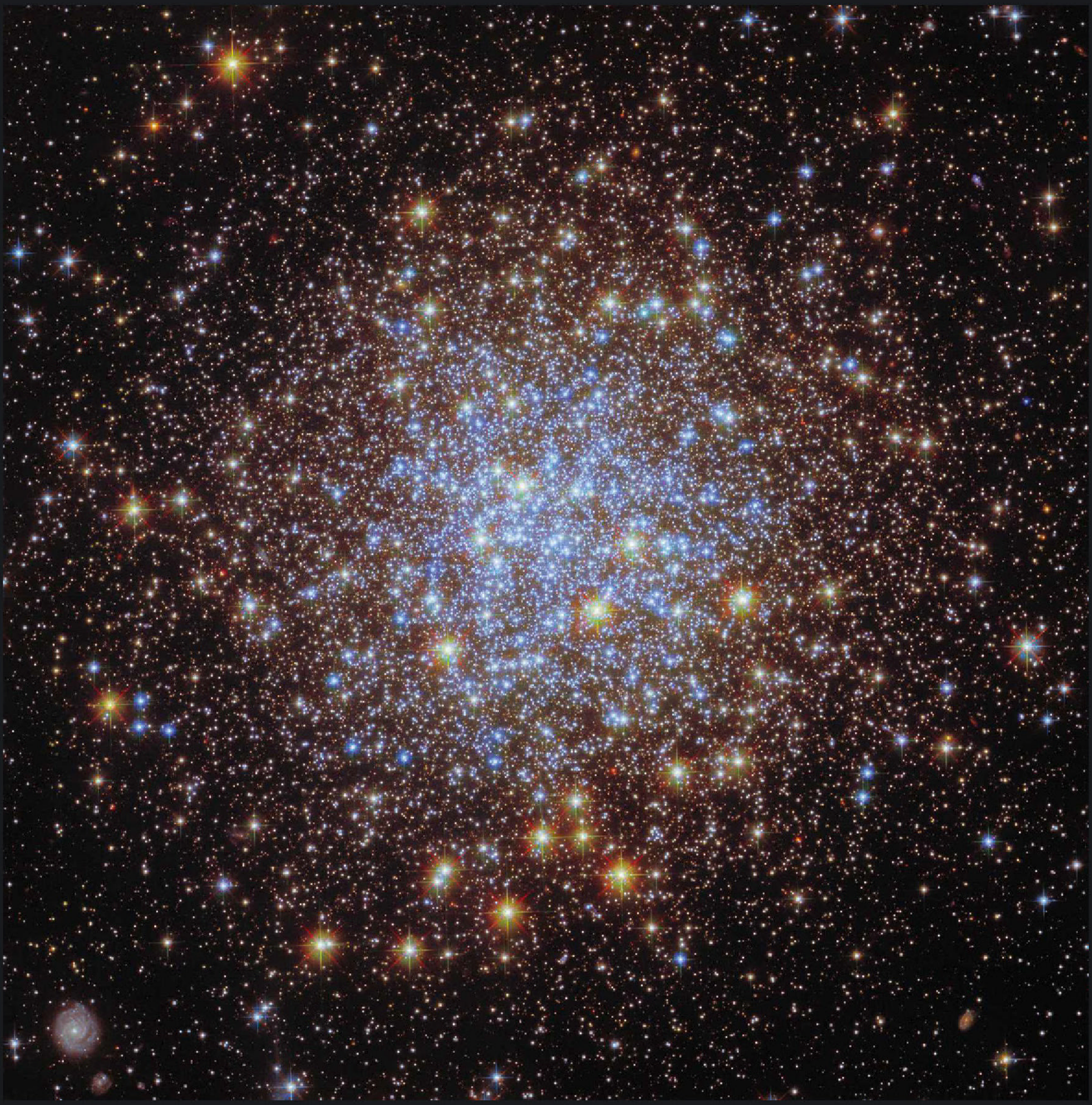
On the left we see Neptune as captured by Hubble, while the right-hand image overlays near-infrared data from Webb. Like all the other gas giants in our Solar System, Neptune has aurorae, seen here as glowing white and cyan patches. Aurorae on Neptune aren't limited to the poles due to the planet's unusual magnetic field, which is tilted at 47° relative to the planet's axis.

Ringing the changes ▷

JAMES WEBB SPACE TELESCOPE, 14 APRIL 2025

This is the Crystal Ball Nebula, NGC 1514. Its two 'rings' – only visible in the infrared – are made up of material ejected from, and now heated by, a dying star at the nebula's heart. The Crystal Ball is believed to be around 4,000 years old and will continue to glow for several millennia to come.





◁ Still shining

HUBBLE SPACE TELESCOPE, 21 APRIL 2025

As part of Hubble's 35th anniversary celebrations, ESA reprocessed and reissued this 2010 image of Messier 72, a globular star cluster some 50,000 lightyears from Earth in the constellation of Aquarius. This new image includes ultraviolet data that reveals a far wider variety of colours than the original.

ESA/HUBBLE & NASA/D. THILKER, NASA/ESA/CSA/STSCI/HEIDI HAMMEL (AURA) HENRIK MELIN (NORTHUMBRIA UNIVERSITY) LEIGH FLETCHER (UNIVERSITY OF LEICESTER) STEFANIE MILAM (NASA-GSFC), NASA/ESA/CSA/STSCI/MICHAEL RESSLER (NASA-JPL) DAVE JONES (IAC), ESA/HUBBLE & NASA/A. SARAJEDINI/G. PIOTTO/M. LIBRALATO

The latest astronomy and space news, written by Anita Chandran

BULLETIN

The finding has implications for how the Universe comes to an end

A weakening of the force

New data suggests that dark energy's pulling power is changing

Dark energy's pull could be weakening over time, according to new results from the Dark Energy Spectroscopic Instrument (DESI) collaboration.

The Universe has been expanding at an accelerating pace since the Big Bang over 13.8 billion years ago, and cosmologists have long believed this expansion was enabled by the Universe's most mysterious quantity – dark energy. Most think dark energy's pulling power is the same now as it was at the dawn of the Universe, an idea that arises from a widely accepted model of the Universe, known as Lambda cold dark matter or Lambda-CDM.

The DESI collaboration put this model to the test by creating the largest 3D map of the Universe ever made and tracking the influence of dark energy over 11 billion years. By overlaying the DESI findings with other data, a more complicated picture of dark energy has started to arise in which its pulling power gets weaker over time.

The DESI collaboration looked at different clues that hint at dark energy's nature, including light from Type Ia supernovae explosions and the cosmic microwave background radiation.

The nature of dark energy could determine the fate of our Universe. If dark energy acts as a cosmological constant, astronomers believe the Universe may end in a 'Big Freeze'. In this scenario, all the matter and energy in the Universe would be spread thin – like too little butter scraped over too much bread. If dark energy does vary with time, this too could have significant implications for the Universe's ending, potentially resulting in a more extreme scenario like a 'Big Crunch', where the Universe snaps back into a singularity, like before the Big Bang.

"Whatever the nature of dark energy is, it will shape the future of our Universe," says Michael Levi from Lawrence Berkeley National Laboratory, who is the director of DESI. "It's pretty remarkable that we can look up at the sky with our telescopes and try to answer one of the biggest questions that humanity has ever asked." **www.noirlab.edu**

NASA/ESA/J. MERTEN (INSTITUTE FOR THEORETICAL ASTROPHYSICS/HEIDELBERG/ASTRONOMICAL OBSERVATORY OF BOLOGNA), AND D. COE (STSCI), ESA, NASA/DAN GALLAGHER

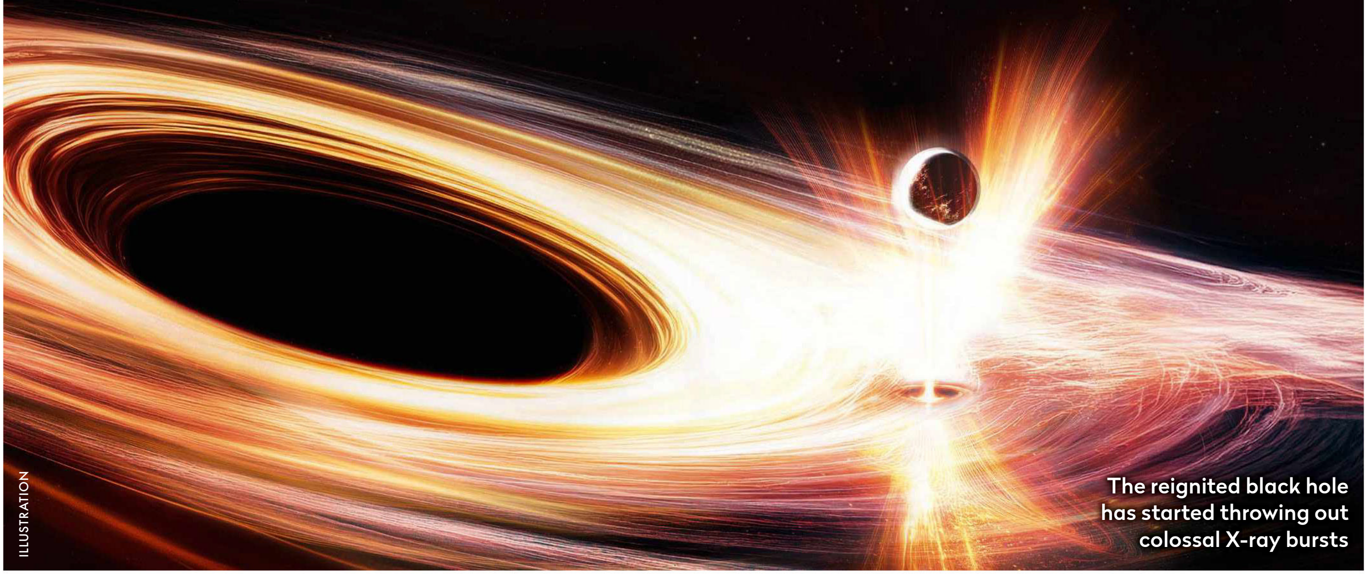
Comment

by Chris Lintott

Cosmologists everywhere will have greeted these results with excitement and a sigh of relief. The huge mystery of what, precisely, the accelerating force we call 'dark energy' is will be much harder to solve if it's a cosmological constant. If the Universe is made that way, we may be stuck.

New cosmological experiments are on the way, but measuring quite how constant the cosmological constant might be is nowhere near as compelling as working out how it's changing. If the DESI results hold up, the field will be invigorated. How dark energy is changing will rule out, or in, our theories about its nature – and let us determine the future of the Universe.

Chris Lintott co-presents *The Sky at Night*



The reignited black hole has started throwing out colossal X-ray bursts

Black hole wakes after decades-long nap

A giant black hole has suddenly come to life in a flurry of X-ray flashes

Black holes are often thought to be hungry giants eating as much matter as they can. But one black hole has left astronomers puzzled. After a nap that lasted decades, Ansky, the black hole at the centre of the SDSS1335+0728 galaxy, has burst back to life in dizzying style.

Astronomers first became aware of Ansky's awakening in 2019, when they caught optical and X-ray outbursts from the black hole. These burps are called quasi-periodic eruptions or QPEs. Supermassive black holes can be active, consuming the gas around them, or quiet, and they can transition between the two states. But this is the first time that scientists have captured a black hole 'waking up' in real time.

Observing QPEs is not unusual, but the size and strength of the explosions from Ansky give scientists pause.

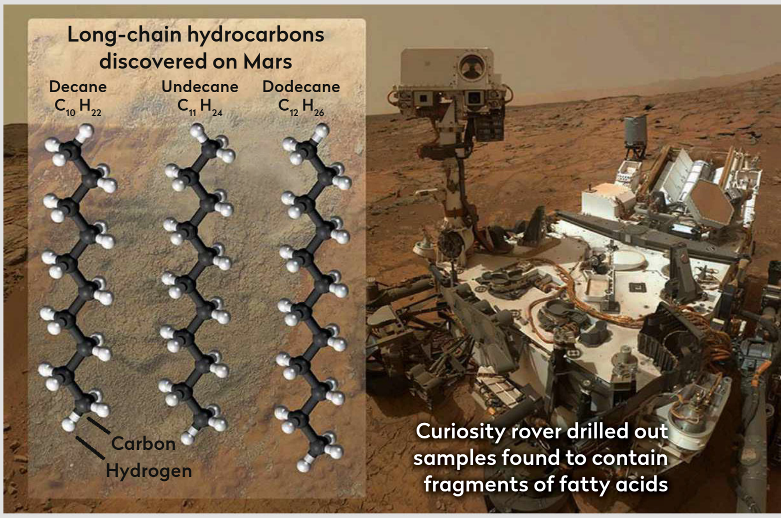
"Each of these eruptions is releasing 100 times more energy than we have seen elsewhere," says Joheen Chakraborty from MIT, who took part in the study. "Ansky's eruptions also show the longest cadence ever observed, of about 4.5 days. This pushes our models to their limits and challenges our existing ideas about how these X-ray flashes are being generated."

What has caused Ansky to flare back to life? The short answer is, we don't know. QPEs can arise when a black hole shreds a star and draws in the pieces through an accretion disc. But this doesn't explain the recurrence of the QPEs, nor does Ansky appear to have recently consumed a star.

"We're still at the point where we have more models than data, and we need more observations to understand what's happening," says ESA's Erwan Quintin. **www.esa.int**

Ingredients of life spotted on Mars

Astronomers discover the longest organic molecules yet on the Red Planet



Curiosity rover drilled out samples found to contain fragments of fatty acids

NASA's Curiosity rover has unearthed the largest carbon chains yet found on Mars. Containing up to 12 carbon atoms, these chains could exhibit similar features to fatty acids, considered some of the building blocks for life on Earth.

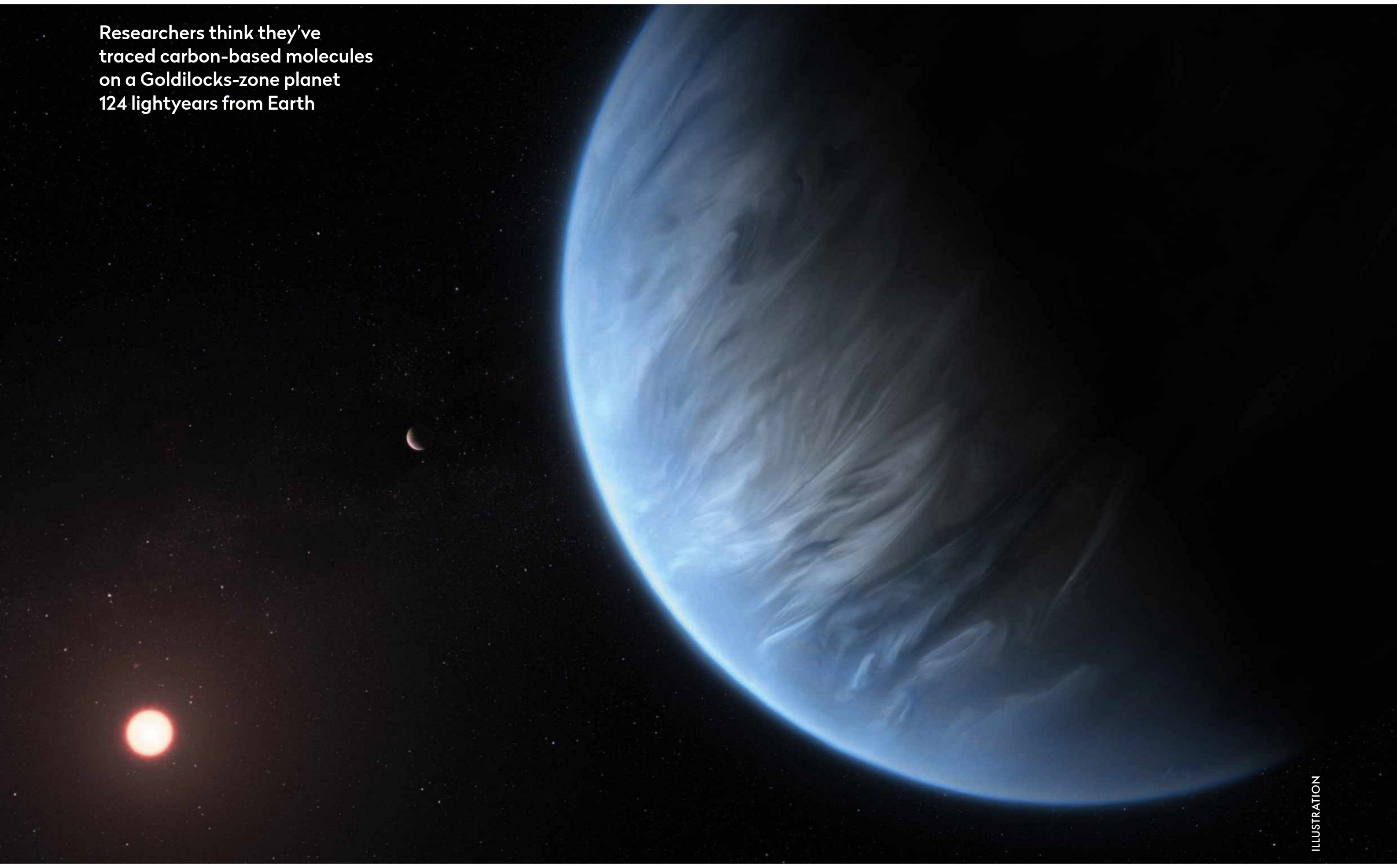
The molecules were found using SAM (Sample Analysis at Mars), an instrument on the Curiosity rover, in a rock sample collected years ago from a dried-up lakebed named Yellowknife Bay. A thorough re-examination of the sample resulted in the discovery of chains of between 10 and 12 carbon atoms long.

Astronomers believe these long carbon molecules, or alkanes, were preserved in clay-rich deposits on Mars, aided by the planet's cold temperatures. They are thought to be around 3.7 billion years old, aligning roughly with when life first emerged on Earth.

We don't yet know how the alkanes appeared on Mars. On Earth, fatty acids are built using pairs of carbon atoms. If ancient life caused these molecules to appear on Mars, we would therefore expect to see an abundance of chains around this length.

Life is not the only explanation. Fatty acids can also be carried by meteorites, formed through chemical interactions in the early Solar System. Meteor impacts may have then deposited these alkanes onto Mars's surface.

Clarity will take more time, more sample collection and possibly the return of samples to Earth. But while this discovery does not directly imply life on Mars, it does suggest a fascinating chemical origin story between our planets. **www.jpl.nasa.gov**



Researchers think they've traced carbon-based molecules on a Goldilocks-zone planet 124 lightyears from Earth

Strongest hints yet of life outside the Solar System

JWST points to a possible biosignature on planet K2-18b, but astronomers urge caution

Whether life exists beyond Earth remains one of the great unresolved paradoxes of our age. Now a team of scientists from Cambridge University claim to have found the strongest evidence yet for potential biological activity on another world.

By pointing JWST at exoplanet K2-18b, 124 lightyears from Earth, they found the molecular fingerprints of dimethyl sulphide (DMS) and dimethyl disulphide (DMDS). On Earth, these compounds can only be formed by life. While the discovery sounds like a watershed moment for humanity, the study's lead scientist Professor Nikku Madhusudhan tempers his optimism: "We are very cautious. We have to question ourselves both on whether the signal is real and what it means."

There are still several leaps required before the team can say for sure that the signal points to life. While on Earth DMS and DMDS are only formed through life, this isn't necessarily the case everywhere in the Universe. The observations have also not yet reached the 'five-sigma' level of statistical significance. This threshold, long considered the gold standard, would correspond to just a 0.00006 per cent probability that the signals arose by chance. The signals from K2-18b currently reach a level of three sigma.

To fully confirm the discovery, the team would not only require more observations, but also a way of either identifying other life-relevant processes on K2-18b or ruling out potential formation alternatives for DMS and DMDS. This is complicated by the fact that K2-18b's planetary conditions are hotly debated. The planet is eight times the mass of Earth and orbits within its star's Goldilocks zone, meaning it could have liquid water on the surface. While Madhusudhan's team favour an ocean world, others claim K2-18b is more reminiscent of a gas planet or one with magma oceans – both inhospitable to life.

The Cambridge team believe they can reach the required five-sigma threshold with 16 to 24 hours of follow-up with JWST. In the meantime, others are analysing the same data from K2-18b to see whether they too find the DMS/DMDS signals. Whether they do or not, what remains remarkable is our ability to search the atmospheres of faraway planets for these faint signs of life. **www.nasa.gov**

ESA/HUBBLE/M. KORNMESSER, BLUE ORIGINX 3

Blast off! Blue Origin springs into action with all-female crew

The 31st excursion of the New Shephard rocket takes a crew of former astronomers and celebrities on a brief spaceflight

An all-female crew successfully launched into space for the first time in over six decades. The 11-minute flight into suborbit took place aboard the New Shephard rocket, an autonomous vehicle operated by Jeff Bezos's private space company, Blue Origin. Suborbital flight refers to entering space, but without the necessary speed to enter a stable orbit around Earth like the ISS.

In the first women-only spaceflight since Valentina Tereshkova's Vostok 6 flight in 1963, the diverse crew was composed of Aisha Bowe, Amanda Nguyen, Gayle King, Katy Perry, Kerianne Flynn and Lauren Sánchez. Amanda Nguyen, a former bioastronautics research scientist, is the first Vietnamese and South Asian woman astronaut. Aisha Bowe, a former NASA rocket scientist, also becomes the first person of Bahamian descent to enter space.

The excursion has met with some cynicism, mostly due to the inclusion of celebrities like Katy Perry and ongoing concerns about the ethics of space tourism. Despite the debate, it's undeniable that Bezos's enterprise with Blue Origin marks a series of firsts for spaceflight. **www.blueorigin.com**

BLUE ORIGIN

SHEPARD
UE ORIGIN

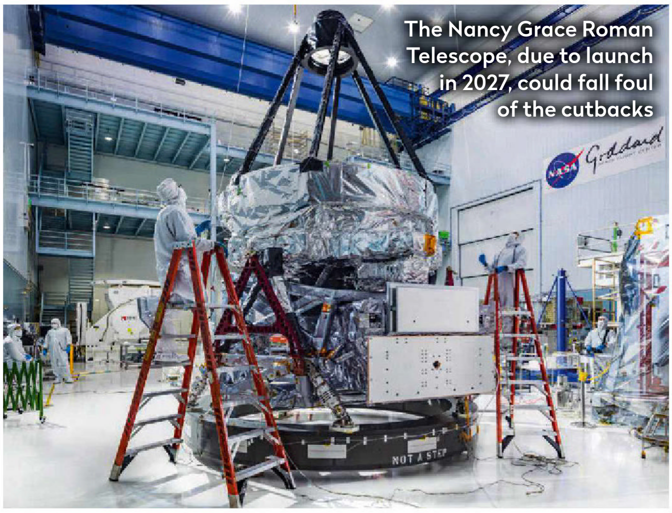
◀ Top: the NS-31 crew (left to right), Lauren Sánchez, Katy Perry, Aisha Bowe, Kerianne Flynn, Gayle King and Amanda Nguyen

Bottom: former NASA intern Amanda Nguyen celebrates making it to space after putting her astronaut dreams on hold to campaign for civil rights

BLUE ORIGIN

Trump takes aim at NASA funding

A draft proposal from the US presidential budget shows severe cuts to planetary science



The Nancy Grace Roman Telescope, due to launch in 2027, could fall foul of the cutbacks

The Trump administration has proposed a series of severe cuts to NASA's funding in a draft version of its budget. The initial budget request calls for an average 20 per cent cut, with severe cuts to heliophysics, Earth science and planetary science budgets. The harshest reduction comes to astrophysics, which has its budget slashed by two thirds, down to around $487 million.

"This is an extinction-level event for NASA science," says Casey Dreier, chief of space policy for the Planetary Society, in a statement to the *Washington Post*.

The proposal has been met with opposition across the political spectrum, but experts are concerned NASA will be forced to make operational plans based on the draft budget as soon as October.

"This is a wholly unserious budget proposal," says Senator Chris Van Hollen, part of the committee that has jurisdiction over NASA's budget. "I will fight tooth and nail against these cuts and to protect the critical work being done at NASA Goddard."

In a joint statement, law-makers Don Bacon, a Republican, and Judy Chu, a Democrat whose district houses NASA's Jet Propulsion Laboratory, said the cuts would "demolish our space economy and workforce… and ultimately surrender the United States' leadership in space, science, and technological innovation".

The move could spell an end to the Mars Sample Return mission and force the closure of Goddard Space Flight Center, home to 10,000 staff. While the proposed budget would support ongoing missions like the Hubble and James Webb Space Telescopes, it "assumes no funding is provided for other telescopes". This would mark an abrupt end to the Nancy Grace Roman Space Telescope, proposed to launch by May 2027. Now nearing its completion, the $4.3 billion observatory would be a successor to Hubble and Webb. Its loss would be a major blow to global astronomy and to US astrophysics.

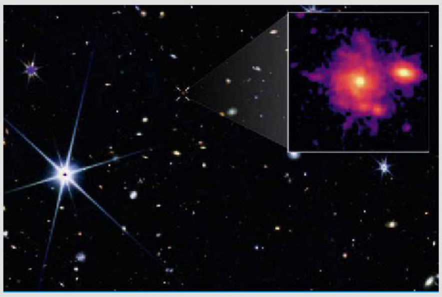
Milky Way's oldest twin discovered

Observations with JWST have uncovered the most distant spiral galaxy candidate known

Spiral galaxies are characterised by their long arms, expanding out from a dense, central region. Our Milky Way is one such spiral galaxy, and now a team led by the University of Geneva has spotted its oldest 'twin' to date, the most distant spiral galaxy candidate ever discovered.

"We named this galaxy Zhúlóng, meaning 'Torch Dragon' in Chinese mythology," says Dr Mengyuan Xiao, lead author of the research study that uncovered the galaxy. "What makes Zhúlóng stand out is just how much it resembles the Milky Way, both in shape, size and stellar mass."

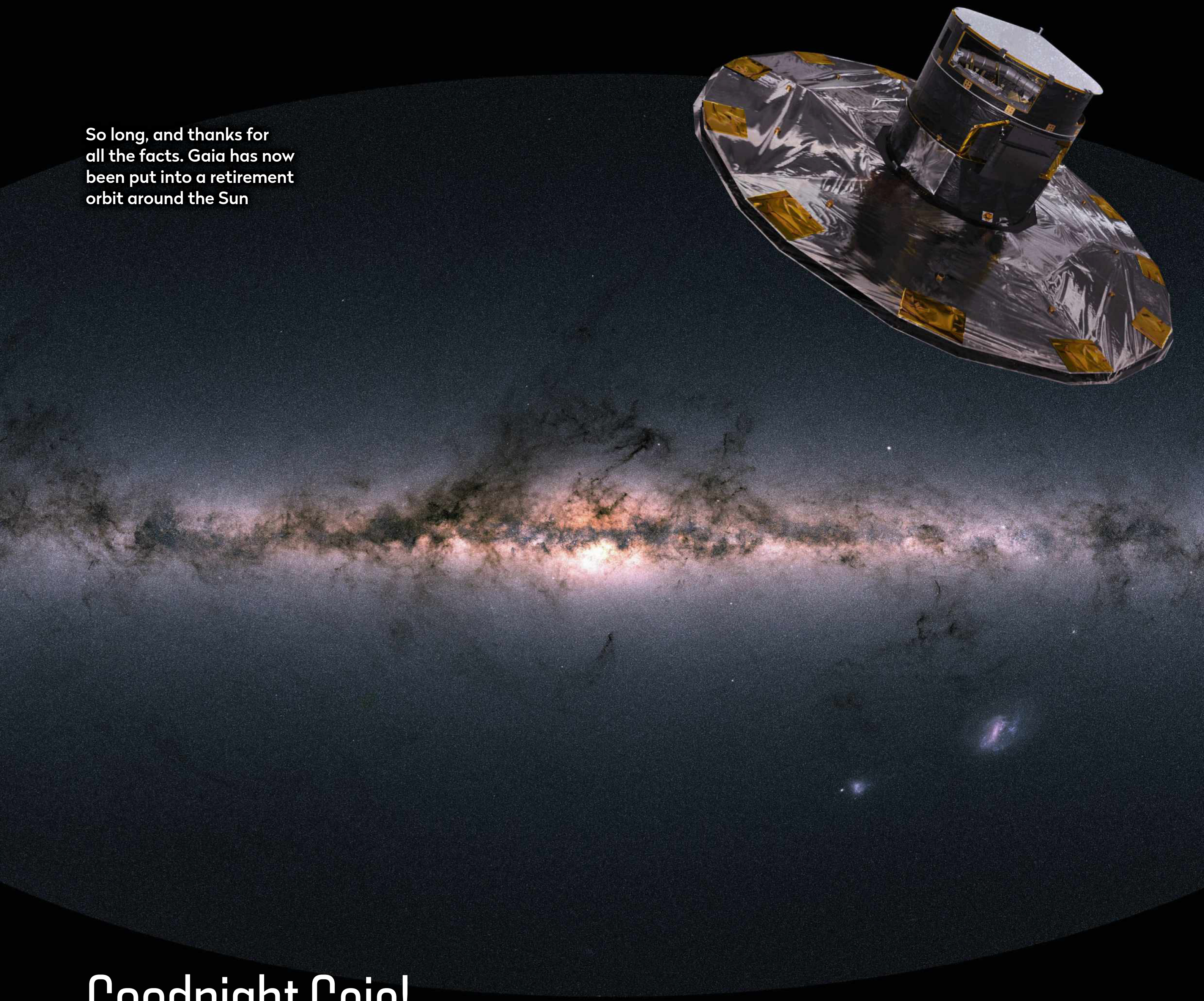
Deep observations with the JWST are able to reveal a surprising amount of detail in the distant spiral galaxy. It is an ultramassive system, with a disc spanning 60,000 lightyears, and contains more than 100 billion solar masses of stars, both of which are comparable to the Milky Way today. Zhúlóng is so far away that JWST is seeing it as it existed just one billion years after the Big Bang. Its structure has surprised astronomers, mostly because of the maturity of its spiral arms. Large spiral galaxies like Zhúlóng and the Milky Way are expected to take several billion years to form. At Zhúlóng's young age, astronomers would have expected it to be small and chaotic in structure.



▲ **Zhúlóng galaxy exhibits defined spiral arms and a large star-forming disc**

The newly discovered ancient spiral is one of the most similar twins of the Milky Way found at such an early period in the Universe's history. By defying conventional understandings of galactic formation, it raises questions about how spiral galaxies really formed after the Big Bang. **www.unige.ch**

NASA GODDARD SPACE FLIGHT CENTRE, NASA/CSA/ESA, M. XIAO (UNIVERSITY OF GENEVA) G. BRAMMER (NIELS BOHR INSTITUTE) DAWN JWST ARCHIVE, ESA/GAIA/DPAC, ESA, TIM ELLISON



So long, and thanks for all the facts. Gaia has now been put into a retirement orbit around the Sun

Goodnight Gaia!

After a decade of scientific operations, ESA's Gaia spacecraft has finally been retired

The Gaia satellite was launched in 2013, with the aim of understanding the Milky Way's formation. Now, after more than 10 years of operations, on 27 March, mission controllers sent the order to begin shutdown procedures, sending the spacecraft into a retirement orbit before powering down for good.

Over the last decade, Gaia has significantly impacted our understanding of the cosmos, producing the largest and most precise multi-dimensional map of our Galaxy. Even after the spacecraft ends its operations, data from Gaia will be a resource for scientists for years to come.

"Gaia's extensive data releases are a unique treasure trove for astrophysical research and influence almost all disciplines in astronomy," says Johannes Sahlmann, a project scientist with Gaia.

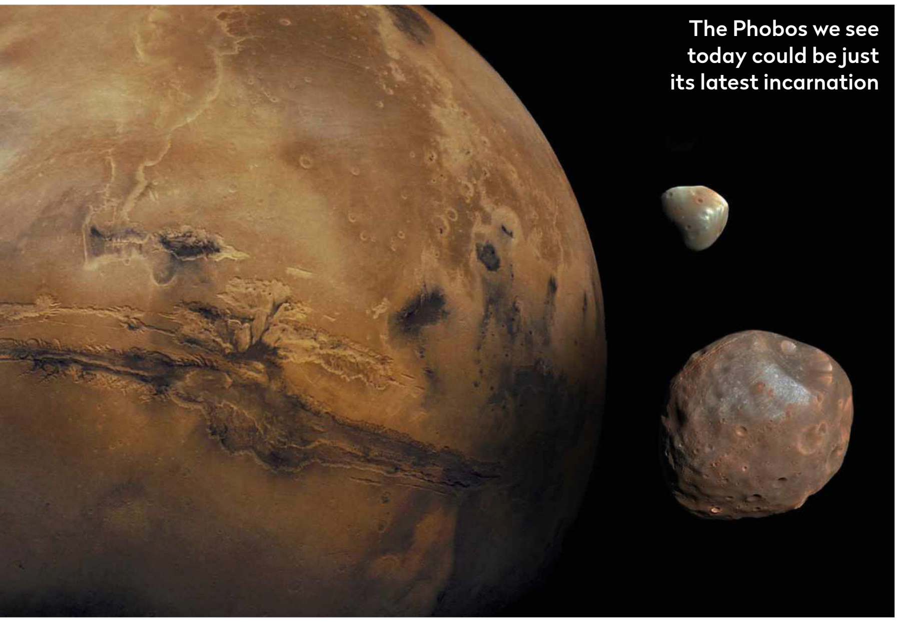
The bittersweet process of decommissioning a satellite requires systematically disabling all the safeguards built to keep the craft running. The lengthy process represents an emotional time for all those who have worked on it.

"We will never forget Gaia and Gaia will never forget us," says Gaia mission manager Uwe Lammers. **www.esa.int**

Reader Tim Ellison captured Gaia in February as it completed end-of-mission engineering tests

Our experts examine the hottest new research

CUTTING EDGE



The Phobos we see today could be just its latest incarnation

Is this reboot 6.0 for Phobos?

Mars's largest moon may have risen from the ashes of a previous satellite

The origin of Mars's two moons, Phobos and Deimos, has long been a matter of debate. The idea that they are captured asteroids has been popular in the past, but the fact that they both orbit close to Mars's equatorial plane means that most planetary scientists today accept it is much more likely they formed from a disc of rock and dust circling the planet. Such a circum-Martian disc was probably formed of ejecta from a giant impact into the Red Planet.

Phobos, the larger and inner of the two moons, is spiralling ever closer to Mars due to tidal effects and will probably be broken apart by these forces within a few tens of millions of years. But Phobos's past could have been even more dramatic.

The traditional hypothesis is that Phobos formed much further out – at between five and six Mars radii – and over the course of billions of years migrated inwards to its current orbit at 2.7 times Mars's radius. However, in 2017 an alternative possible history was proposed. This posited a process whereby multiple cycles of inwardly spiralling moons become fragmented into a disc (as is thought will happen with Phobos), at the outer edge of which a new, smaller moon forms. Gravitational interactions with the ring will initially drive this moon into a wider orbit, until the ring dissipates and the moon spirals inward again, only to become fragmented itself.

Such a process could have repeated around six times over Mars's history, with each new moon being about a fifth the mass of the one that came before. If this is the case, then Phobos is just the latest incarnation in this cycle of creation and destruction, and is only around 100 million years old. This could also explain the mystery of why Deimos has an orbit that is circular but tilted to a high inclination. Interactions with the inner ring would have excited this moon's inclination.

Ancient or newborn?

It's a compelling idea. But is there evidence in the dynamics of the Mars–Phobos–Deimos system today that would support either the traditional view of a distant Phobos slowly migrating inwards or this new model of planet–ring–planet cycles? Or, to put it another way: is Phobos ancient or newborn?

Matija Ćuk at the SETI Institute in Mountain View, California, and his two colleagues at the department of physics and astronomy at Purdue University in Indiana, have used computer simulations to model the past orbital evolution of Phobos. They found that both competing hypotheses are compatible with the present orbits of Phobos and Deimos, although the data available can't be used to determine how far out Phobos formed or its age. They do note, though, that other observations support the recent formation of Phobos from a ring. The overall shape of the moon matches that expected to have been produced by tidal forces at 3.3 times Mars's radius – where the outer rim of a disc would lie.

But Ćuk says that more information is needed to be able to tell for sure. For instance, the Martian Moons eXploration (MMX) probe, a JAXA mission to bring back samples of the surface of Phobos, will launch in 2026 and may allow scientists to put limits on the age of the moon.

> **"Such a process could have repeated six times, with each new moon being about a fifth the mass of the one that came before"**

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Two Possible Orbital Histories of Phobos* by Matija Ćuk, Kaustub P Anand and David A Minton
Read it online at: arxiv.org/abs/2503.12691

NASA/JPL-CALTECH/UNIVERSITY OF ARIZONA, NASA/ESA/R.M. CROCKETT (UNIVERSITY OF OXFORD/U.K.) S. KAVIRAJ (IMPERIAL COLLEGE LONDON AND UNIVERSITY OF OXFORD/U.K.) J. SILK (UNIVERSITY OF OXFORD) M. MUTCHLER (SPACE TELESCOPE SCIENCE INSTITUTE/BALTIMORE/USA) R. O'CONNELL (UNIVERSITY OF VIRGINIA/CHARLOTTESVILLE/USA) AND THE WFC3 SCIENTIFIC OVERSIGHT COMMITTEE

Zombie galaxies live again

Seemingly dead galaxies apparently burst back to life and form new stars

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

Finding out how star formation stops is one of the biggest problems in astrophysics. On average, as the Universe ages, galaxies shift from being rich in star formation, lit up by the brilliant blue light of massive new stars, to quiescent, quiet places.

The process is known as quenching, but a new study making use of data from the Hubble Space Telescope suggests that quenched galaxies might not be as dead and dull as previously thought.

Led by Michael Rutkowski in Minnesota, the authors have identified what we might call 'zombie galaxies', quenched but still undergoing sporadic and really quite significant bursts of star formation.

The galaxies in question are among the most massive in the Universe, exactly the type we'd expect to have stopped forming stars long ago. From objects included in the UVCANDELS survey (Ultraviolet Imaging of the Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey Fields), one of many deep imaging surveys undertaken by Hubble in recent years, the team picked galaxies with a stellar mass greater than 10 billion times that of the Sun, and which showed no signs of active black holes (to avoid contamination of their final sample).

Signs of life

The redshifts of the galaxies lie between 0.5 and 1.5, so we're looking back 5–9 billion years, from the time just after the cosmic rate of star formation peaked. The 1,067 galaxies remaining in the sample look like the big, boring ellipticals that one would expect to have ceased star formation early. In the local Universe, it's spiral galaxies that host most stellar nurseries.

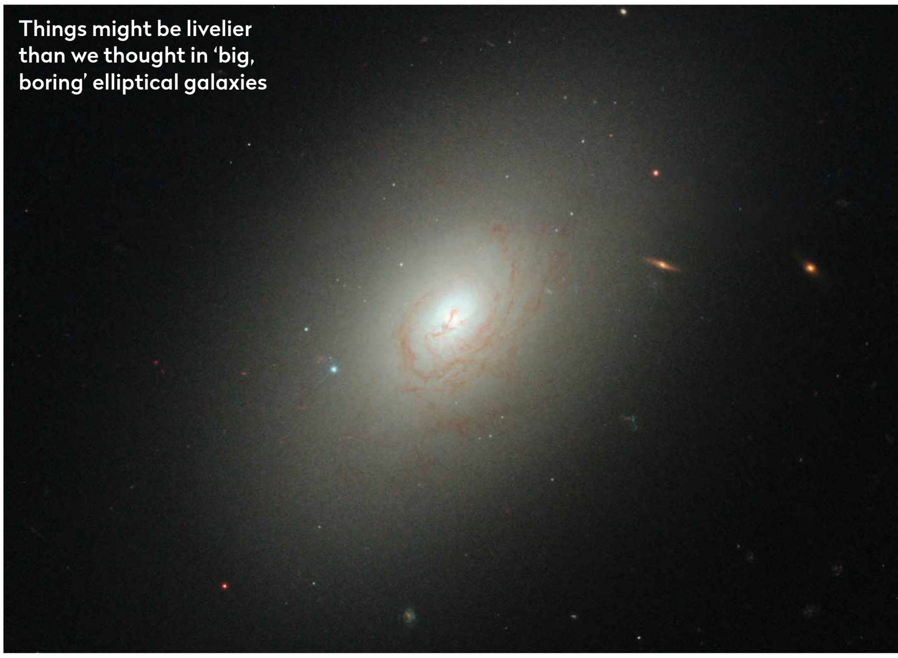
What's interesting is that the team have ultraviolet observations for these galaxies. Brilliant, massive young stars which only live for a short while once formed, shine brightly in this part of the spectrum. That means that ultraviolet light can be used to trace hidden star formation, which is what the team did.

Within the sample, 15 per cent were bright enough for the team to surmise these seemingly dead-looking galaxies had undergone a recent burst of star formation, forming no more than 10 per cent of their stars in the last billion years. For a massive galaxy, even a few per cent represents a substantial episode of star formation. The zombie galaxy, newly revived, lurches on.

> **"Even a few per cent represents a substantial episode of star formation. The zombie galaxy, newly revived, lurches on"**

One plausible explanation for their rejuvenation is that we're seeing the result of mergers; consuming a younger system provides a fresh transfusion of gas from which stars can be made. This hypothesis, more vampire than zombie, is, however, ruled out by the absence of a link between how dense an environment a galaxy lives in and the odds of it having recent star formation. Mergers happen more in denser environments, so we should see a strong connection if they're responsible.

What's really happening must be stranger, some internal process that we don't yet have a handle on. It's possible that the black holes at the centre of the galaxies, in a quiet mode so their growth is not easily spotted, may be having an effect. Plans are already being made for better images and spectra of these intriguing systems. After all, everyone loves a zombie movie, don't they?

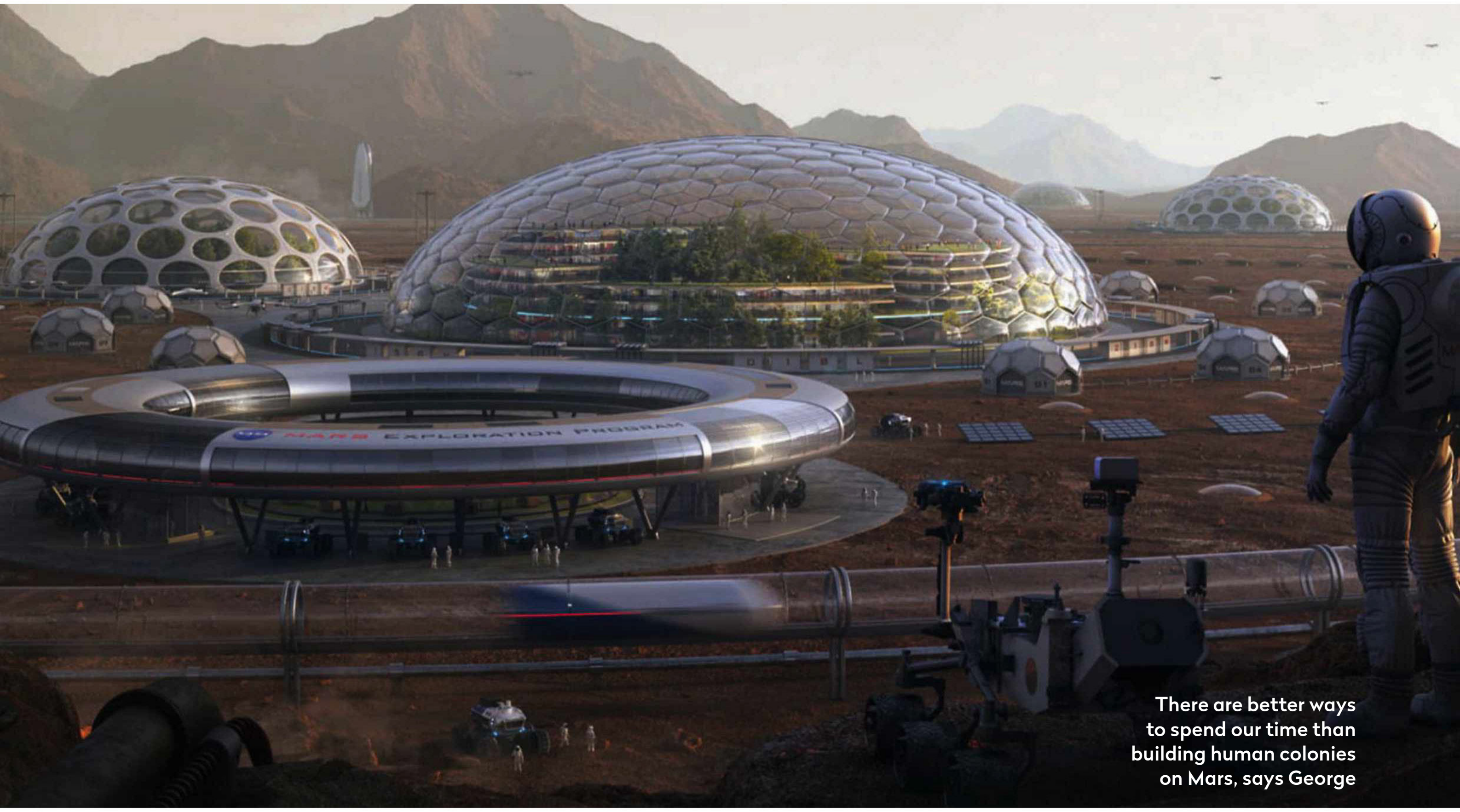


Things might be livelier than we thought in 'big, boring' elliptical galaxies

Chris Lintott was reading... *Recent Star Formation in 0.5<z<1.5 Quiescent Galaxies* by Michael J Rutkowski et al.
Read it online at: arxiv.org/abs/2504.05511

Behind the scenes of *The Sky at Night* TV show

INSIDE THE SKY AT NIGHT



There are better ways to spend our time than building human colonies on Mars, says George

With the May episode of *The Sky at Night* looking at all things Mars, presenter **George Dransfield** asks why so many people are drawn to the Red Planet

What's the first thing that comes to mind when you think of Mars? I ask because that dusty red rock has been a documented feature of human culture for at least four millennia, so I think most people will have a 'thing' they immediately associate with the planet. For me, it's Jeff Wayne's synthy masterpiece adaptation of HG Wells's *The War of the Worlds*. Specifically, the first track (although all of it is excellent). More specifically: "but still... they come." If you've never heard it, pause your reading here and go listen; I guarantee you nine minutes of giddy goosebumps.

Our crimson planetary sibling loves a bit of media attention, both factual and fictional. *Mars Attacks!*? Fictional. Interesting black specks on rocks that could be evidence of long-ago microbial activity? Factual. A fella across the pond saying he will have colonised Mars within a decade? Factual that he said it, but otherwise very much fictional.

SPONGY101010, NASA/JPL-CALTECH/MSSS, LAURIE NOBLE/GETTY

George Dransfield researches exoplanets at the University of Birmingham and is a presenter on *The Sky at Night*

But, hear me out here: I do not think humans should go to Mars. Certainly not to live and probably not even to visit. Don't get me wrong; it's a wonderful little planet. If I discovered an exo-Mars twin, I'd be thrilled. After all, it's in the so-called 'habitable zone' of its host star and it's got an atmosphere of sorts. But compared with Earth, Mars is absolutely pants. Its measly atmosphere is mostly carbon dioxide, it's dustier than the top of my wardrobe and it's really chilly. Also, as far as we know, it's a bit too dry.

It's no Earth 2.0

The whole narrative of us living on Mars relies either on terraforming the planet (not a thing we can do) or living inside dome-like mini habitats. Even if this were possible, it would take a comically large amount of time and money to achieve anything remotely like a human colony. And what could we do instead with that time and money? Address some of the problems we have on Earth.

> ***"Hear me out: I do not think humans should go to Mars. Certainly not to live and probably not even to visit"***

Because yes, the reasoning behind sending humans to Mars, at least in some circles, is that it would be a solid back-up plan if things go south on our home planet. But I cannot stress enough how daft an idea I think this is. Clearly, things are getting dire here climate-wise, but it's not yet unsalvageable. The other thing to consider is that *we* are the problem here, not our planet of residence. As the adage goes, 'wherever we go, there we'll be', so taking ourselves somewhere less hospitable and hoping for an altogether better outcome feels like an odd choice. Also – and this point is of supreme importance – there are no dogs on Mars, so really what's the point?

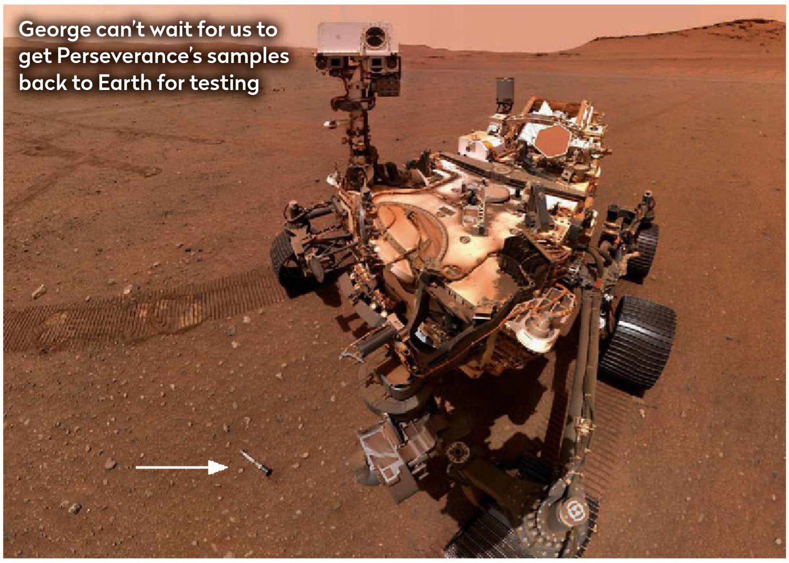
Carry these thoughts with you as you watch May's episode of *The Sky at Night*. Last year, I met Mekhi Desi at Astroscale (she took me into their clean room – a high-precision assembly room – and I got overexcited) and she's back this month as our guest presenter. Mekhi spoke to Dr James Lambert from Pulsar Fusion about the company's progress in developing new propulsion systems to shorten the journey time to Mars. This is incredibly cool from an engineering perspective, and their Sunbird rocket legitimately feels like sci-fi in action. No spoilers – you'll have to watch it to fill in the gaps!

I think it's absolutely thrilling that we might be able to reduce Solar System travel times – not so we can go there in person, but so we can more feasibly get samples back from Mars and other bodies. Sample-return missions are where it's at for me. Bring me all the space rocks. Analyse them in labs. Make outstanding graphs.

Regardless, the discussion around manned missions to the Red Planet will continue. Those who question the ethics and efficiency of such a plan will continue to push back. But there's grandstanding to be done, and profit to be made, so the chances of this debate ending any time soon... well, they're a million to one, I'd say.

How to watch

Catch the show on the BBC iPLAYER


George can't wait for us to get Perseverance's samples back to Earth for testing

The Sky at Night
JUNE

Located in southeast London, the ROG is a great monument to British astronomy

Greenwich: A Journey through Space and Time

The Royal Observatory in Greenwich is celebrating its 350th anniversary this year. In this episode, *The Sky at Night* team take a look at this historic institution at the heart of British astronomy (perhaps best known for being the reference point for the prime meridian) and explore its past discoveries and the latest research moving these early findings forward.

BBC Four, **9 June**, 9:50pm (first repeat will be on BBC Four, **13 June**, 00:30am)
Check www.bbc.co.uk/skyatnight for more up-to-date information

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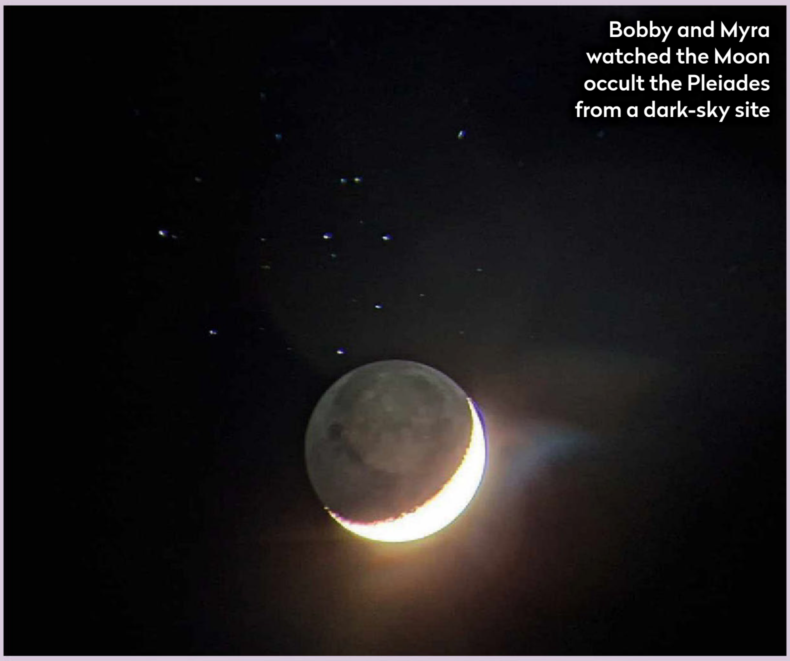
MESSAGE OF THE MONTH

A night with the Seven Sisters


Bobby and Myra watched the Moon occult the Pleiades from a dark-sky site

On 1 April, my wife Myra and I with our Celestron Inspire 100AZ refractor took off to a less light-polluted site, resulting in a very enjoyable night's viewing. We arrived just before twilight, which gave us plenty of time to set things up, allowing us to experiment with lenses and telescope positions. With the sounds of geese in the background, we started to observe the Moon, Jupiter and various other bodies in the night sky, which we never get tired of doing.

Then our focus turned to the Pleiades with the occultation with the Moon, so we thought we would have a go at photographing the event, something we are totally inexperienced in doing. Myra took a number of images using her smartphone and selected the best one to send (right). All in all, we found it a very enjoyable and productive evening.

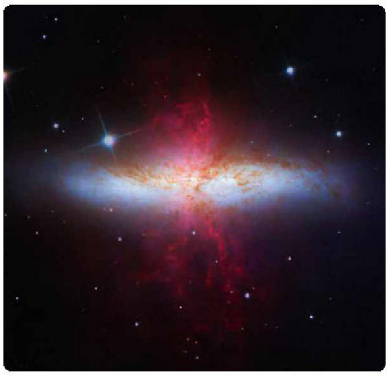
Bobby Wyre, via email

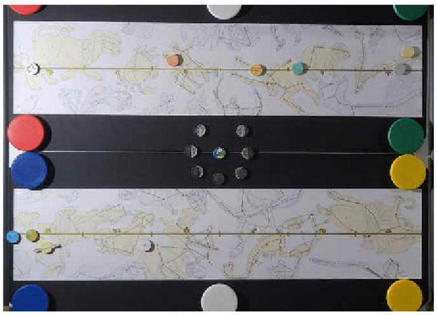
What an atmospheric image Myra captured. Your message really conveys the wonder of watching lunar occultations, Bobby. Thank you! – ***Ed.***

Tweet

Rikesh Patel
@_Rikesh • 8 April

Cosmic drama: 12 hours of integration at f/3.9 from Bortle 6 skies in the northwest of England. M82 captured in detail. My most refined image in five years of astrophotography. #astrophotography @skyatnightmag




▲ Creative Gareth even colour-coded for the seasons in his detailed magnetic zodiac

Cosmic crafts

After musing on how orreries (unless they're ridiculously proportioned) don't really give a good impression of how the Solar System looks from Earth, I decided to make a substitute for myself – a magnetic zodiac! I plotted over 300 stars near the ecliptic, made some magnetic planets and put the whole thing on a magnetic whiteboard. Here it is (above), set up for the 'parade' of seven visible planets in February.

Gareth Wilkes, Cambridge

I spy Starlink

I witnessed an extraordinary astronomical event on 6 April. I was looking out for shooting stars and satellites from my hotel balcony in Fuerteventura around 05:45 (GMT). On a track between Spica (Virgo) and Arcturus (Boötes), I noticed one bright satellite moving pretty quickly towards the east which appeared to be in low Earth orbit. But then about 15 degrees behind there was another on the same track, and then another. In the end, I counted 13 equally spaced satellites in a train moving across the sky. I was astonished. A Google enquiry revealed that these were from a Falcon rocket launched 2.5 hours earlier from Florida. Its payload was 27 Starlink satellites, released one by one about 90 minutes ▶

BBC Sky at Night MAGAZINE

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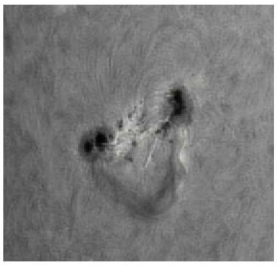
▶ before I saw them. It's possible they were heading for India to provide internet coverage over that continent.

Being an avid amateur astronomer for the last 60+ years, I'm still amazed by what can be seen at night given the right conditions.

Steve Rainey, Potters Bar

What's this?



I captured this late morning image of the Sun on 11 April 2025, showing sunspot group 4055. There's a twisting loop of gas between the end sunspots. I've never seen this before. It doesn't look like a prominence, being on its side, or a filament. What could be causing it?

James Robertson, via email

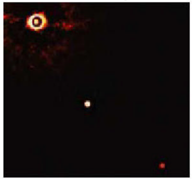
Thanks for your image, James. You didn't mention whether this was captured in hydrogen-alpha (Hα), but we've assumed it is from the detail. It appears to show a filament bridging the sunspots, but the chromosphere is very weak, so the sunspot groups look more like they would through a white-light filter. This could be caused by using an Hα etalon with too wide a passband or an Hα filter that's not totally on-band. ***– Pete Lawrence***

Instagram

antoine_deneboude • 20 April

It was meant to be a simple stop for the night, but the Highlands had other plans. No clouds for days[...] then the aurora came, pillars of light rising silently above, as if the sky itself was reaching down to touch Earth.

Family portrait



ESO/BOHN ET AL

Thank you for the fantastic article, 'Yes, astronomers have captured real photos of alien worlds beyond our Solar System. Here are some of the best' (www.skyatnightmagazine.com). The one I liked most was TYC 8998-760-1 b and c (above). I love how it feels like a family portrait from another star system. I really appreciate you showcasing the incredible work being done in this field. It's a story that makes space feel close and full of possibility.

John Corban, via email

SOCIETY IN FOCUS

We set up **Eden Valley and Penrith Astronomy Group** (EVAPAG) in January 2024 and our first meeting was reasonably well attended but could have gone better. Two minutes in, the data projector bulb blew and we ended up watching our first presentation crowded around a laptop! Not an auspicious start, but by the next meeting, Morland Village Hall (our current home) had a new LCD projector and we were back in business. Our attendees have now grown to around 35, young and old, and over 150 followers on Facebook.

Some members are beginners, while some have an amazing knowledge of astronomy and experience with telescopes and astrophotography. We've been invited as expert speakers on Radio Cumbria and BBC Radio 5 Live. One of our members created our new website, while another designed our logo. What an amazing range of talents our group has.

▲ New group EVAPAG in Cumbria hope to secure funding for their own observatory

In February, we did our first major outreach event as part of the Yorkshire Dales Dark Skies Festival, a mixture of presentations, exhibitions and observing using 10-inch Dobsonians, a Dwarf 3 and Seestar S50. It was a sellout and everyone had a great night. So what's next? We hope to apply for funding for our own observatory, so it might be worth watching this particular region of space!

Nick Higgett, EVAPAG group leader
▶ www.penrithastro.org

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Christopher
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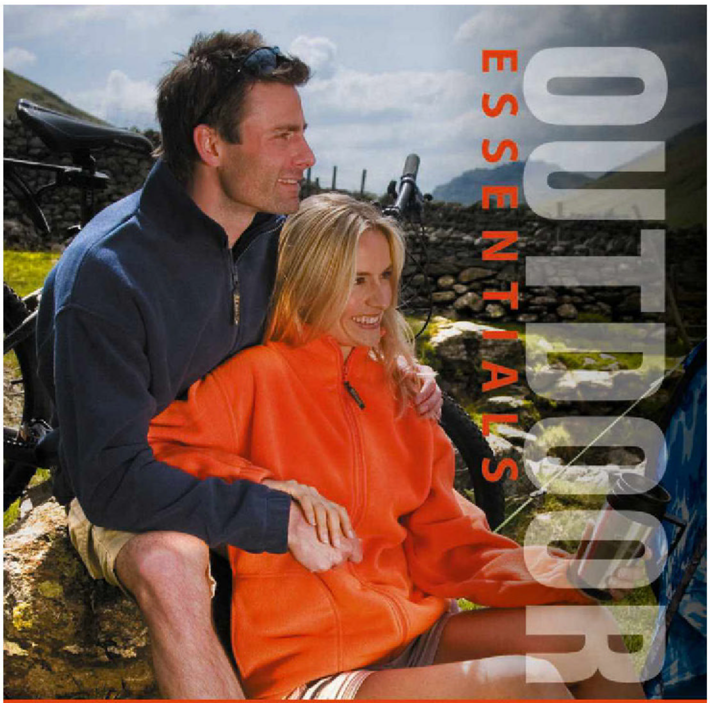
christopherward.com



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This all-day event on **7th June 2025** (10 am — 5pm) will be hosted by Cardiff University School of Physics and Astronomy.

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FIELD OF VIEW

Joys from the black stuff

Scientific research shows that time spent outside in the darkness with the stars is good for our mental health, says **Mark Westmoquette**

KATE EVANS/FOLIO

Author of *The Mindful Universe*, astronomer and mindfulness teacher **Mark Westmoquette** lives with his young family in London and can be reached at www.markwestmoquette.co.uk

I've spent a lot of time indoors in my life. I've been a professional astronomer and the job is, surprisingly, mostly desk-bound – data crunching, reading the literature and writing papers. Even an amateur stargazer probably spends more hours at the computer processing images and preparing their tech than outside with their telescope.

These days I'm doing more writing, which I also tend to do indoors. And if I spend too long inside, I start to feel stale. I find myself shrinking away from the world, and the longer it goes on the more I want to retreat. It takes effort sometimes to get outdoors. I don't mean just down to the shops, but really out in nature. But when I do, the stale feeling is blown away and I find myself expanding out into the world again.

Research shows that time in nature can bring an improvement in mood, a sense of increased wellbeing, happiness, meaning and purpose in life, and encourage positive social interactions, as well as a decrease in mental distress (Bratman et al., 2019, *Science Advances*).

In most of these studies, 'nature' has meant being in a green space like a forest or garden, but there's increasing evidence that blue spaces (like rivers or the sea) have equivalent benefits ('Blue Space Forum: Health and Inequalities', UK Government report, 2024). And I'd like to suggest another environment: black spaces – which is to say, being out under the stars. After all, the night sky is just as much a part of our natural world as the forest. In fact, one recent study found that people with a greater connection to the night sky had better mental health and felt happier (Barnes & Passmore, 2024, *Journal of Environmental Psychology*).

Scientists theorise that being in nature helps our mental health for several reasons. Firstly, since our ancestors evolved in wild settings, we possibly all have an innate drive to connect with nature and we find plants, water (and the stars) relaxing and soothing. Secondly, spending time in nature seems to stimulate our parasympathetic nervous system's 'rest and digest' response, which shifts us out of the fight-or-flight mode, lowering stress levels, making us feel rested and rejuvenated (Capaldi et al., 2015, *International Journal of Wellbeing*).

To benefit fully from nature's effects, it's important to have an open mind rather than one full of opinions, facts, to-do lists or personal agendas. If we approach being out in nature with a sense of curiosity, then curiosity can easily lead to wonder. And wonder is the precursor to feeling awe. Awe arises from a strange combination of fear and wonder. It's the feeling we get in the presence of something vast that challenges our everyday sense of self and understanding of the world. Awe is well known to have a powerful positive effect on mental health (Piff et al., 2015, *Journal of Personality and Social Psychology*).

It lifts us out of our everyday thoughts and worries, quietens our usual critical self-talk and connects our individual self to a much bigger whole. Awe, as meditation teacher Sharon Salzberg says, is "the absence of self-preoccupation". I'd say that is a big factor in sustaining good mental health.

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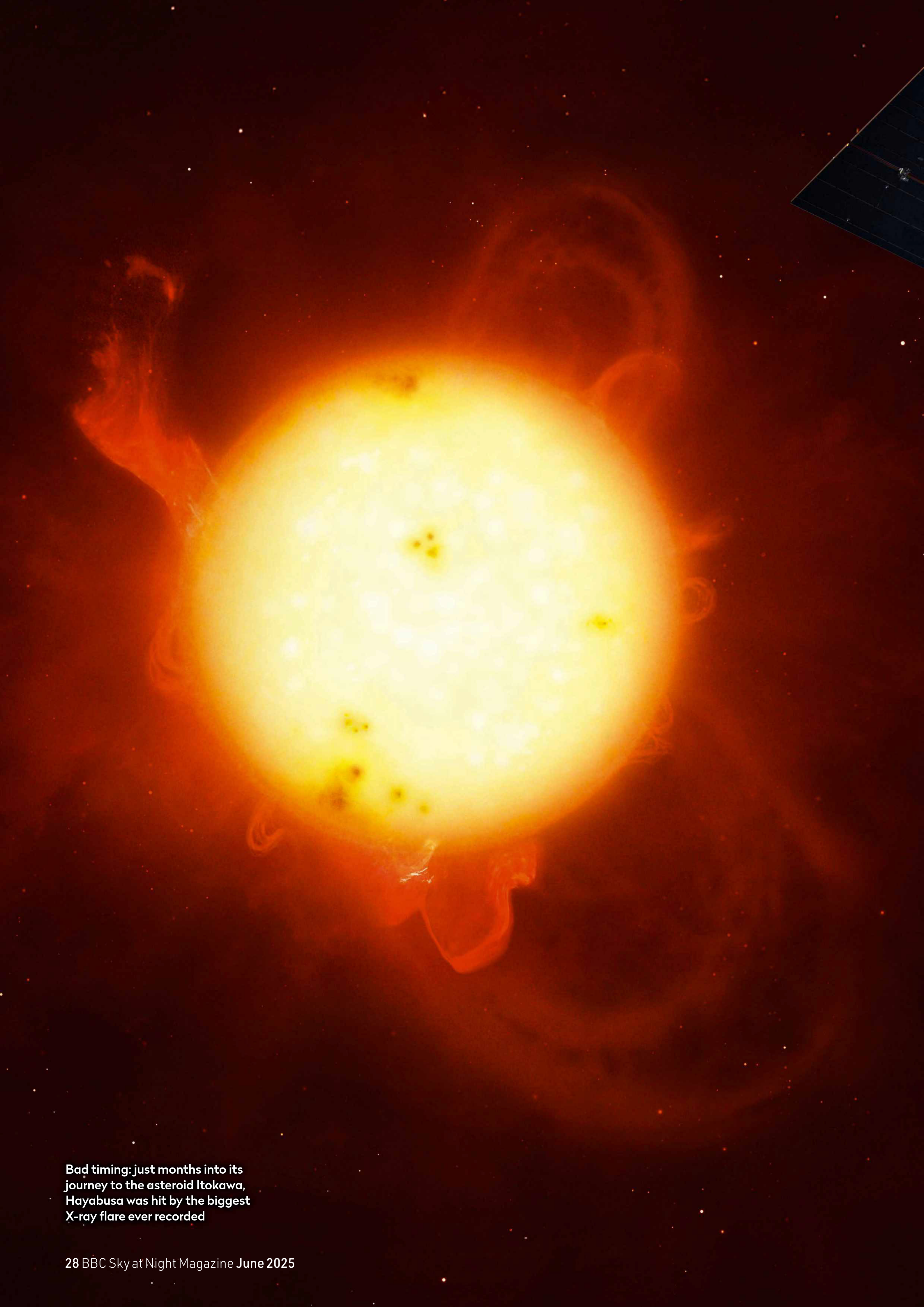


Bad timing: just months into its journey to the asteroid Itokawa, Hayabusa was hit by the biggest X-ray flare ever recorded

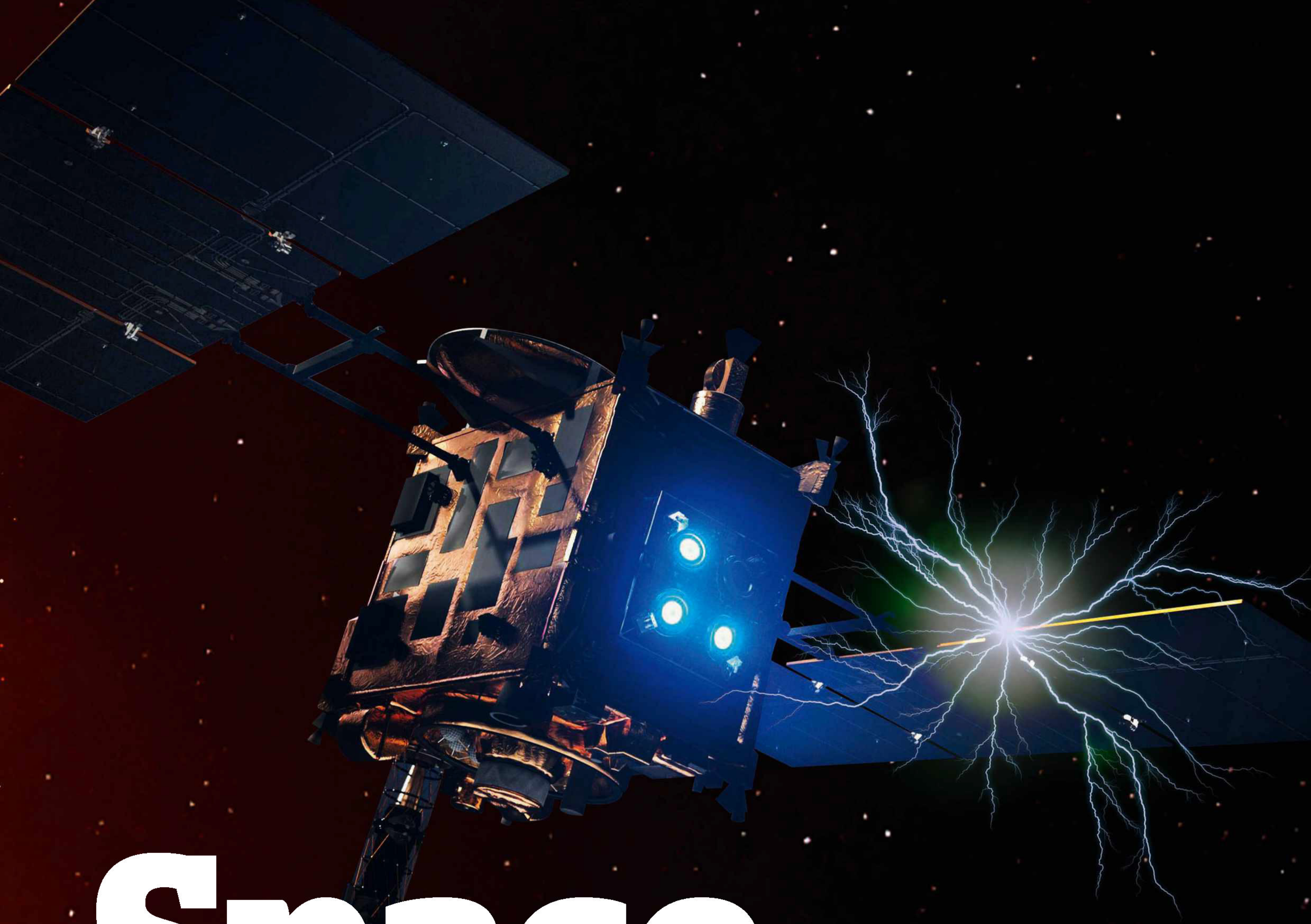


ILLUSTRATION: MARK GARLICK/SCIENCE PHOTO LIBRARY/GETTY, JAXA

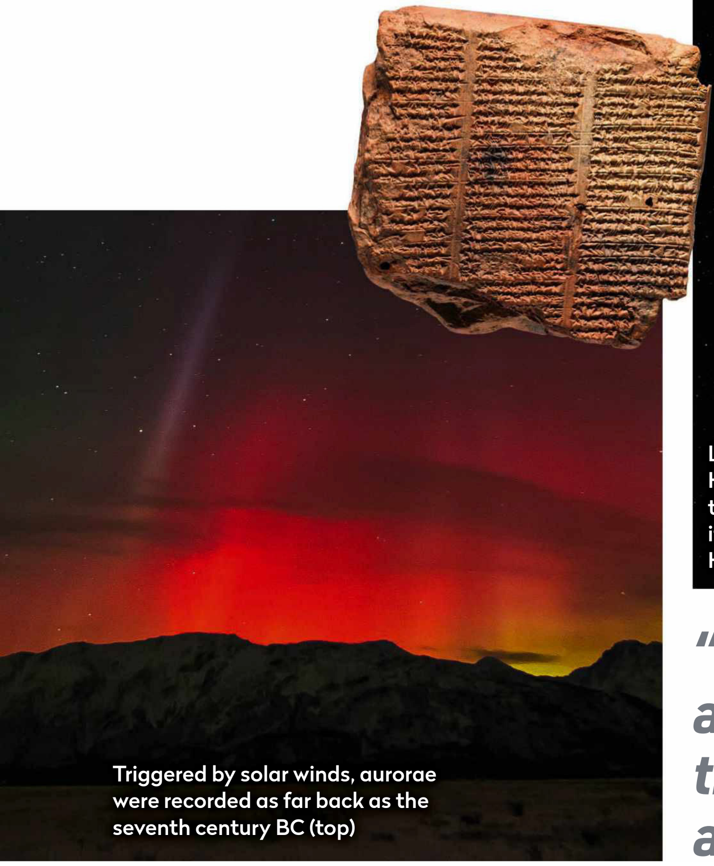
Space weather

Spaceflight's biggest danger

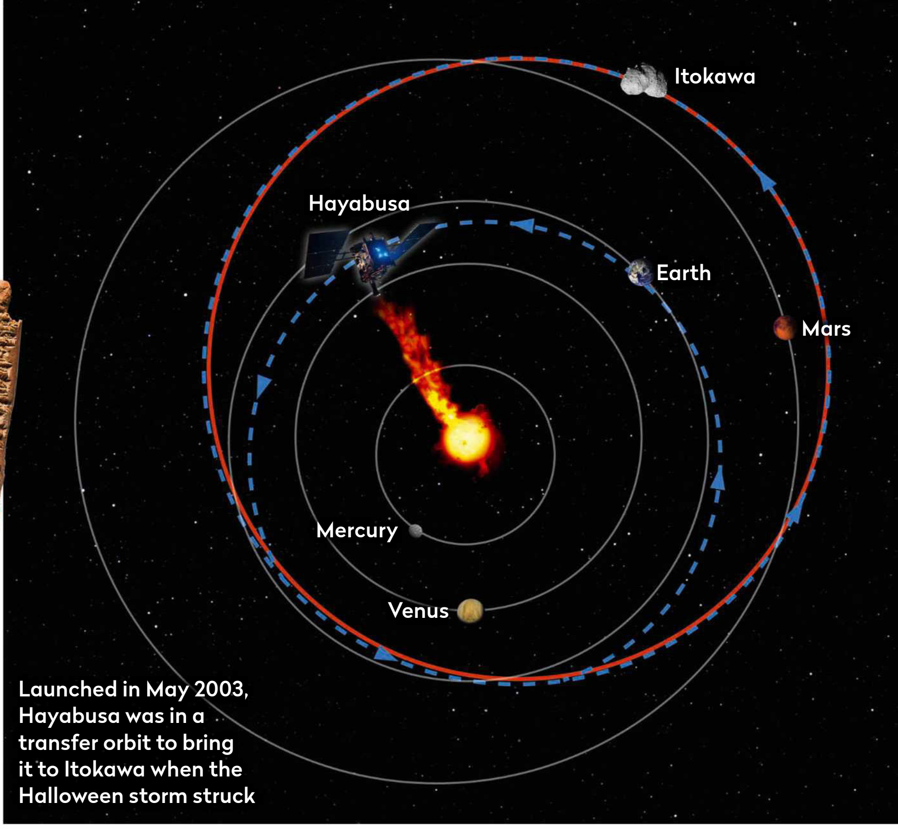
The Hayabusa mission was almost destroyed by one of the most hazardous events a spacecraft can experience – a solar storm. **Hayley Smith** looks back at the mission

It was 15 years ago this month, on 13 June 2010, that the world watched as a beleaguered traveller finally arrived home, after a long and perilous journey back to land. The trouble began in 2003, as All Hallows' Eve approached. All seemed calm as the vessel Hayabusa (Japanese for *mighty falcon*) sailed through the darkness towards uncharted shores. Unbeknown to the crew, though, the ship was about to be hit by one of the fiercest storms in recorded history.

This could be an account from a 15th-century ship's log, but it is in fact a tale of the Space Age. Hayabusa was a robotic spacecraft sailing through interplanetary space on a two-year journey to rendezvous with asteroid 25143 Itokawa when it was battered by a series of massive eruptions unleashed by the Sun. The 'crew' in this case was the ground team, watching helplessly from the safety of their vantage point in mission control back on Earth. ▶



Triggered by solar winds, aurorae were recorded as far back as the seventh century BC (top)



Launched in May 2003, Hayabusa was in a transfer orbit to bring it to Itokawa when the Halloween storm struck

> *"These charged particles are constantly flowing from the Sun out into space at over a million miles an hour"*

▶ Hayabusa, operated by the Japan Aerospace Exploration Agency (JAXA), planned to learn about Itokawa by studying its history, shape, composition and topography, providing a wealth of data for scientists on the ground to learn from. In a daring grand finale, the spacecraft was to attempt the first-ever controlled landing on an asteroid, collecting a sample of material from the surface to return to Earth for further study. It also carried a small rover named MINERVA (Micro-Nano Experimental Robot Vehicle for Asteroid), designed to hop across the surface collecting data.

All appeared to be going to plan until the ship was caught in inclement weather, as so many of its terrestrial counterparts have been before it. In this case, the weather was 'space weather', a barrage of charged particles and electromagnetic radiation driven by the volatile moods of the Sun.

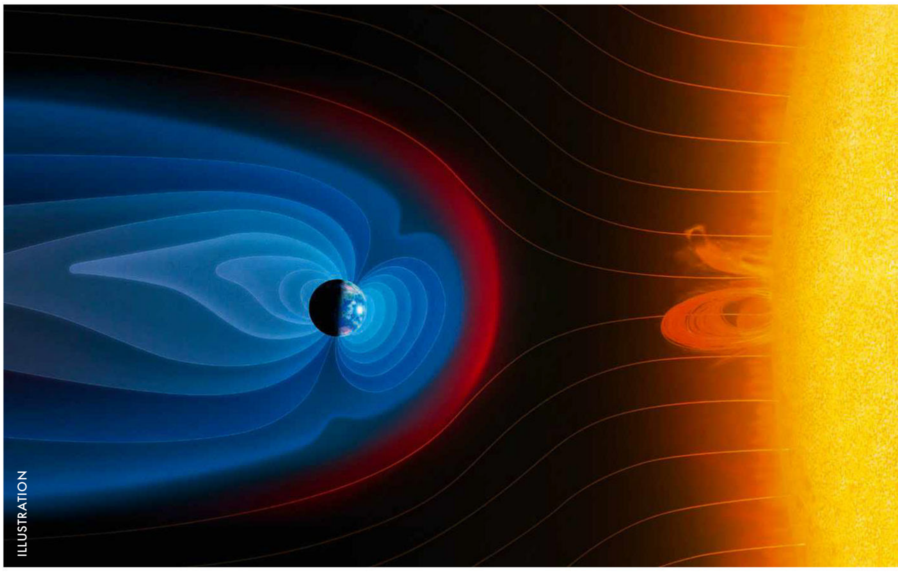
Perils of the solar wind

The people of Earth have been observing the effects of space weather for millennia, long before we sent our vessels skywards. Mesopotamian stone tablets dating back over 2,500 years describe red clouds and glowing skies, now thought to be the first written account of the aurora borealis or Northern Lights. These eerie lights were feared by early observers, who described them as bad omens or roaming dragons lighting up the night with their fiery breath.

We now know that the 'flames' are not caused by vengeful dragons but by charged particles, mostly protons and electrons, interacting with Earth's magnetic field and atmosphere. Known as the solar wind, these charged particles are constantly flowing from the Sun out into space at over a million miles an hour, bombarding our planet and everything else in the Solar System with radiation.

Fortunately, our magnetosphere, the shield created by Earth's magnetic field, does a good job of protecting us from this onslaught. When the intensity of the radiation is high enough, the particles can funnel along our magnetic field lines at the poles and down into our atmosphere, energising the gases there to create the beautiful dancing displays of light we know as the aurora.

▼ **Like a shield, our magnetosphere deflects the solar wind and radiation from the Sun**



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▲ A coronal mass ejection (CME) caused by a hyperactive, persistent sunspot region during solar maximum, captured by NASA's Solar Dynamics Observatory in May 2024 (left) and a resulting Northern Lights display (right) seen unusually far south, in Essex, England

Solar storm season is now

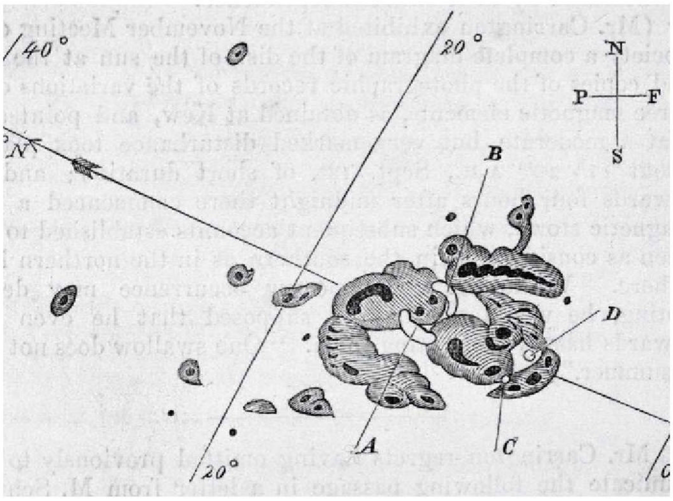
The Sun is at solar maximum, the prime time for big solar storms

On 15 October 2024, solar scientists announced that we had entered solar maximum, the peak of the Sun's approximate 11-year cycle of activity, which is expected to last for around a year. In May 2024, a CME sparked the strongest geomagnetic storm since Halloween 2003 and we were treated to beautiful displays of the aurora here in the UK. Fortunately, we've learned a lot since the 2003 event. Better space weather forecasting and improved radiation hardening of electronic components meant most spacecraft were undamaged.

Solar maximum occurs because the Sun is made of plasma, an intensely hot soup of charged particles that, when in motion, generate magnetic fields. At solar minimum, the magnetic field of the Sun has a relatively simple shape that is concentrated at the poles. However, the Sun rotates faster at the equator than at the poles, and this rotating plasma drags the magnetic field around with it, causing it to become more and more tangled and complex.

This violent twisting of the magnetic field drives the formation of sunspots, flares and CMEs. When we reach solar maximum, the magnetic field is in its most chaotic state and the number of sunspots and violent eruptions peaks. At this point, the Sun's magnetic field flips, the north pole becomes the south and vice versa, and the Sun begins to settle again as we journey towards the next minimum.

In addition to providing the ever-present solar wind, the Sun can suddenly belch huge amounts of radiation out into space in the form of solar flares or coronal mass ejections (CMEs). Solar flares are sudden bright flashes of electromagnetic energy travelling at the speed of light, while CMEs are part of the solar atmosphere thrown out in enormous clouds of plasma. Although quite different, they often occur together and can be collectively described as solar storms.



▲ Astronomer Richard Carrington's 1859 sketch of the giant sunspot region that launched a devastating CME towards Earth

The frequency of these storms depends on where we are in the Sun's somewhat predictable 11-year cycle of activity. At solar maximum, the Sun is at its most violent and active, with huge eruptions more commonplace, while at solar minimum it settles down like a sleeping giant – quiet for a time but certain to wake with a temper.

If directed towards Earth, a CME can cause disruption to our magnetosphere, known as a geomagnetic storm. These can last for many hours. During such times, we ground dwellers are treated to more powerful aurorae, often extending down to lower latitudes, as we have seen recently over the UK. In addition to the aurora, the influx of charged particles can cause a whole host of problems for our technological society. The changing magnetic field can cause unexpected currents to flow in electrical cables, causing power cuts, electrical disturbances and damage to underground pipelines.

Stories dating back hundreds of years talk of ships running aground due to mysterious compass bearing errors, evoking images of sailors stranded on the rocks, staring up in wonderment, as the aurora danced above. In 1859, an enormous solar flare and associated CME, known as the Carrington Event, produced aurorae said to be the most breathtaking ever seen. Meanwhile, the currents it induced at ground level ran amok, disabling telegraph systems around the world. Telegraph operators reported electric shocks, sparks flying and being able to send messages even after the system was disconnected, as if it was working by magic.

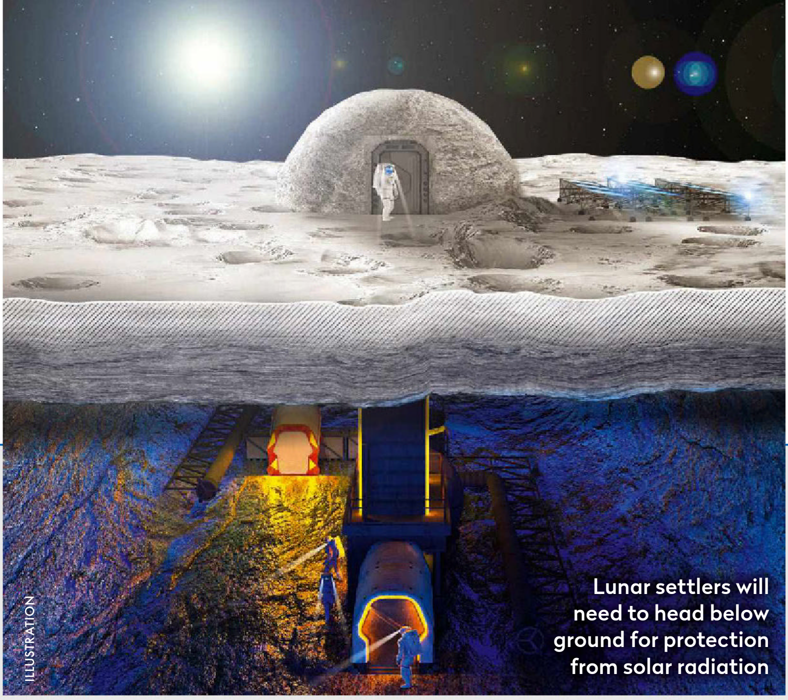
The storms also change the density of Earth's upper atmosphere, the ionosphere, leading in modern times to radio blackouts, GPS positioning errors and increased atmospheric drag on satellites.

Spacecraft in jeopardy

Without the full protection of our atmosphere and magnetic field, spacecraft are particularly vulnerable to the effects of space weather. Charged particles can cause currents to flow in unexpected places, leading to electrical discharge that can damage sensitive components. Random signals cause systems to turn on and off, or thrusters to suddenly ▶

Solar weather's effect on humans

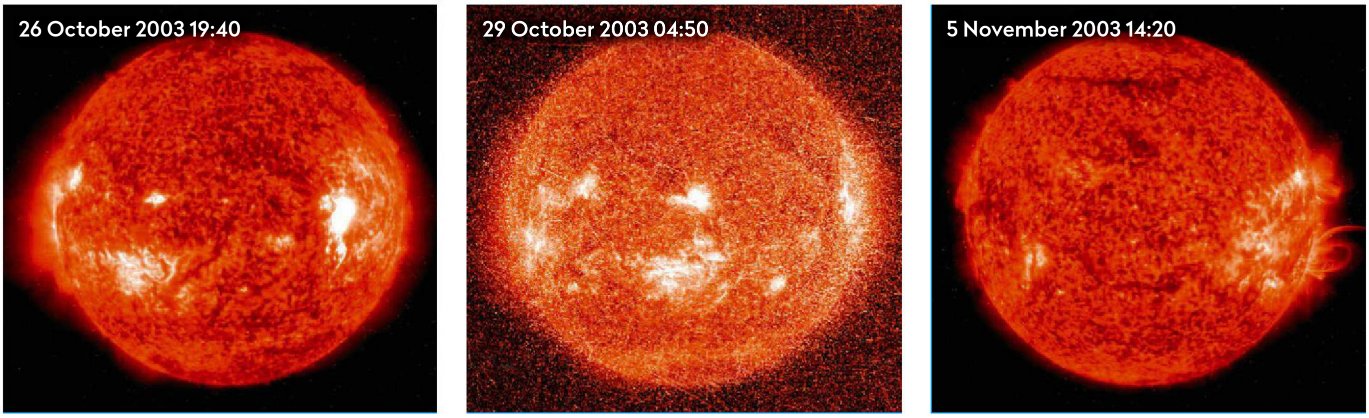
Solar storms can be a serious health risk for any astronauts in space



Lunar settlers will need to head below ground for protection from solar radiation

The 2003 storms sent ISS astronauts Michael Foale and Alexander Kaleri running – or floating – for cover. They sheltered in the Zvezda service module, the most shielded location aboard the ISS, cutting their radiation exposure by 50 per cent. The ISS orbits within Earth's magnetosphere and this, along with the shielding provided by the station, is enough to keep astronauts safe when the weather outside is lousy.

For explorers heading further afield, such as the Artemis astronauts returning to the Moon, or future Mars colonists, it's a different story. In August 1972, between Apollo 16 and 17, there were a series of powerful solar storms that would have given the astronauts radiation sickness had they been in space at the time. The situation wouldn't have been much better had they been at their destination, since the Moon doesn't have much in the way of a magnetic field or atmosphere. In fact, if astronauts had been walking on the Moon in August 1972 without the protection of their spacecraft, the result could have been fatal. Careful spacecraft design and improved space weather forecasting will both be essential to protect future long-distance voyagers, and it may be wise for them to construct subterranean colonies when they arrive, utilising layers of rock and soil for protection from radiation.



▲ **Stills of some of the largest solar outbursts ever seen, the Halloween 2003 storms that wrecked Hayabusa's plans**

► fire, as if there is a ghost in the machine. Any spacecraft using solar cells can expect a gradual drop in efficiency as the solar wind blasts their surfaces, causing an increase in electrical resistance, but a severe storm can multiply this effect many times over.

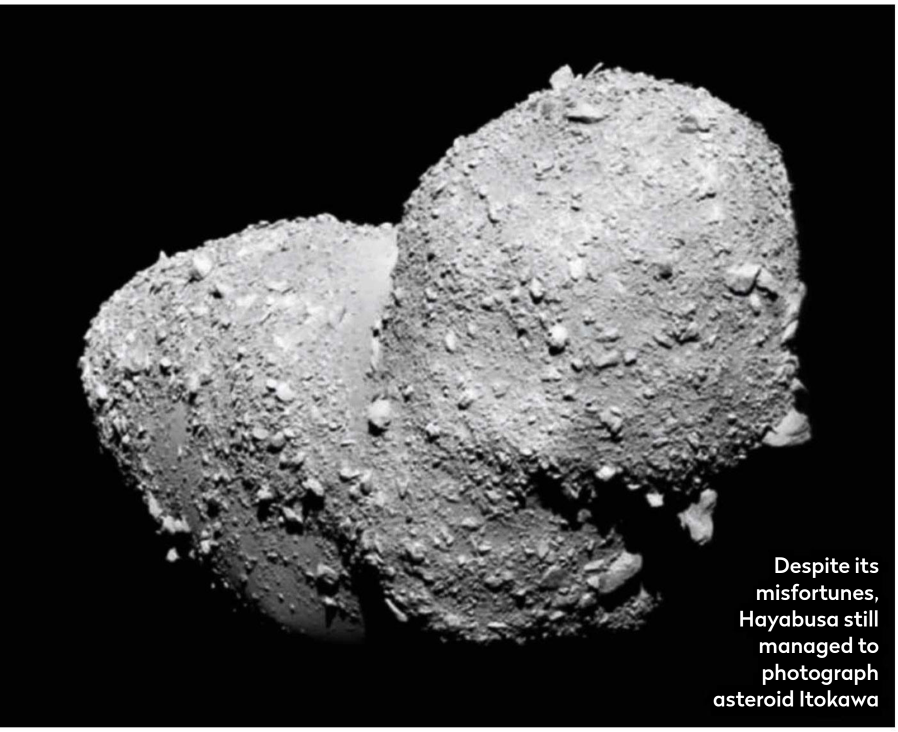
These effects can be mitigated somewhat by careful design and shielding, but weight is money when it comes to spaceflight and there is a trade-off between a failsafe design and the cost of the mission. Whenever there is an electrical fault, spacecraft are programmed to go into safe mode, ceasing any operations that are not strictly necessary and pointing their solar panels at the Sun to maintain power. This gives the ground crew time to work the problem. Space weather forecasting by organisations such as the USA's National Oceanic and Atmospheric Administration (NOAA) can sometimes give notice that a storm is imminent, allowing spacecraft to be switched into safe mode in advance, protecting sensitive systems.

On 4 November 2003, as Hayabusa was on its way to asteroid Itokawa, the Sun unleashed the most powerful X-ray flare ever recorded, along with a CME that bathed the little spacecraft in radiation. The rare event was much more powerful than anything Hayabusa – or any other spacecraft – had been designed to withstand. The Halloween storms caused irreparable damage to several other missions, including the loss of the Martian Radiation Environment Experiment aboard Mars Odyssey.

Hayabusa struggles on

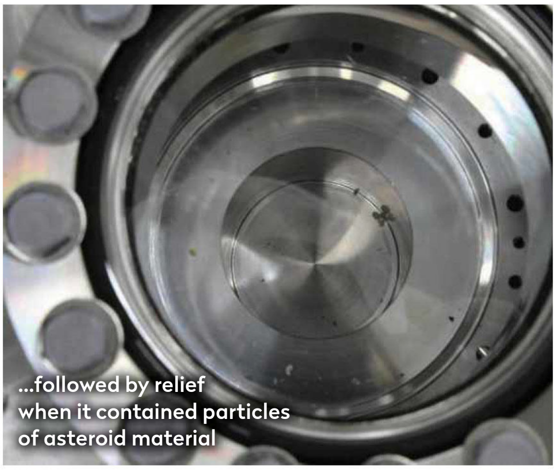
But tough Hayabusa survived and limped on. It was not unscathed, however. The radiation scoured the craft's solar cells to such an extent they could no longer get full power to the ion drives. The planned summer 2005 rendezvous with Itokawa became impossible, meaning time spent at the asteroid would be reduced, but the intrepid explorer still got there, three months later than planned, on 12 September.

NAEBLYS/GETTY, NASA/GODDARD SPACE FLIGHT CENTER SCIENTIFIC VISUALIZATION STUDIO, JAXA/EDITED BY THE PLANETARY SOCIETY, JAXA X 2, JAXA/JSPEC



Despite its misfortunes, Hayabusa still managed to photograph asteroid Itokawa

Breaths were held when the spacecraft's sample capsule landed...



...followed by relief when it contained particles of asteroid material

▲ Hayabusa2 returned a much bigger sample – this time without taking a battering from the Sun

The problems continued as Hayabusa began to explore the unmapped terrain of Itokawa. There was a thruster leak and communication problems, and part of the attitude control system was lost. The Minerva rover floated off into space without ever touching the surface, never to be seen again. Despite all this, Hayabusa achieved its goal of making the first controlled landing on, and ascent from, an asteroid, touching down twice in November.

Even this was fraught with complications though. Hayabusa hovered next to the Sun-heated asteroid for longer than intended, causing the craft to overheat, while the sample-collection mechanism failed. It was unclear whether the landings had successfully gathered any material.

The journey back to Earth suffered even more complications, as thruster problems caused the spacecraft to miss its return window. It would take another three years to make the journey back home. By the time Hayabusa returned to Earth, two of its four ion engines had failed and several batteries were dead. But the capsule did make it home, beautifully demonstrating the importance of redundant systems – built-in backup arrangements that can take over if the primary ones fail – for missions travelling in the unpredictable environment of space.

Hayabusa touched down in Australia on 13 June 2010 after an epic seven-year journey of more than one billion kilometres, and when scientists finally prised open the hatch, they found a tiny treasure trove containing 1,500 precious grains of ancient asteroid material.

Though weighing less than 1 gram (0.03oz), this priceless bounty showed that Itokawa contains traces of water, lending support to the theory that asteroids delivered water to Earth's oceans during the 'late heavy bombardment' era of the early Solar System.

These ancient asteroids, which may have paved the way for all life on our planet, left behind clues hidden within their siblings that not even the fiercest of storms could stop us from finding.

In 2014, JAXA took a second run at the mission with its launch of the spacecraft Hayabusa2 to rendezvous with the asteroid Ryugu. This time, the mission returned a total of 5.4g (0.19oz) of asteroid material, showing what the original mission could have achieved if it hadn't been so unlucky. While the tenacious first Hayabusa managed to return triumphant against all the odds, its battering at the hands of the Sun starkly demonstrated just how much havoc space weather can wreak.

Hayley Smith is a physics teacher, freelance science educator and long-time stargazer

Astronomers now think the stones of Stonehenge mark the 'major lunar standstill', a phenomenon that only occurs every 18.6 years

Stonehenge and the Moon

Unlocking the secrets of lunar standstill

A rare lunar event this year is uncovering mysterious links between the iconic ancient monument and the Moon, as archaeologist **Jennifer Wexler** explains

Two years ago, I was standing in the car park at the Stonehenge Visitor Centre on a cold, clear December evening. I had only recently started working for English Heritage and it was a few weeks before the winter solstice. The Sun was slowly setting, a large, bright-red sphere on the western horizon. Just as it dipped below the horizon, I turned and was shocked to see another giant red orb rising above the eastern horizon – the Moon.

It felt like a cosmic moment, the cycling of a glowing red orb that briefly dipped into the underworld to only rise again in triumph, and I was in awe. In that instant, I realised why the wide open spaces of Salisbury Plain, where Stonehenge is located, have been a place for observing the skies for millennia.

As modern humans living in urban environments awash with light, sometimes we forget how prominent the night sky would have been to people in the past. We know that the movements of the Sun, Moon and stars influenced our ancient ancestors, because around 5,000 years ago, at the end of the Neolithic (or New Stone) Age, the first farmers (who had arrived on British shores about a thousand years earlier) began to build extraordinary things.

Monumental tombs, stone circles and henges were all developed on a grand scale, and as people transformed their world, they looked to the skies. Many of these were aligned with the Sun on the solstices or equinoxes (when night and day are of equal length), including Stonehenge in England and Newgrange in Ireland. These monuments were built not only to help track the yearly movements of the Sun, but also to connect to its regenerative power.

▲ **We know Stonehenge is arranged to align with the summer (top) and winter (bottom) solstices, but its stones may also track the Moon**

KARL HENDON/GETTY, CHRISTOPHER ISON/ALAMY STOCK PHOTO, HERITAGE IMAGE PARTNERSHIP LTD/ALAMY STOCK PHOTO

Residence of the Sun

The Sun was of key importance to these early farmers, because the survival of their crops and animals relied on accurately predicting its movements over the course of the day and year. Stonehenge, in particular, was carefully designed to align with the movements of the Sun. When the circle was constructed 4,500 years ago, the enormous sarsen stones were precisely arranged to frame these key moments in the yearly cycle. On the summer solstice the Sun rises over the Heel Stone and on the winter solstice it sets behind the tallest trilithon at the centre of the circle. This central 'Sun axis' at the heart of Stonehenge suggests that it was a special place of worship and celebration created to enact this cosmic ritual. But what role did the Moon play?

Astronomers have long studied the various possible astronomical alignments connected to Stonehenge. While observations of the Sun's connection to the monument go back to the 18th century, the Moon's connection has been more ephemeral. It was not until the 20th century that ▶

▲ **Predating Stonehenge, Calanais on the Isle of Lewis was carefully designed to mark the Moon's major standstill every 18.6 years**

▶ astronomers suggested there may be a possible link between Stonehenge and the Moon. This was based on observations of the Moon alignment at another ancient monument, Calanais, on the Isle of Lewis off the west coast of Scotland.

Around the same time that Stonehenge was being built, the standing stones and avenue making up the complex stone monument at Calanais were rearranged to align with the full Moon's path from rising to setting. Skimming the horizon, the Moon shines into the centre of the circle at the southern end of the Calanais monument as it sets. Could the Moon have played a similar role at Stonehenge?

At Calanais, this phenomenon only occurs every 18.6 years, during a two-year period called a major lunar standstill, when the northernmost and southernmost positions of the Moon at moonrise and moonset are at their furthest apart along the horizon.

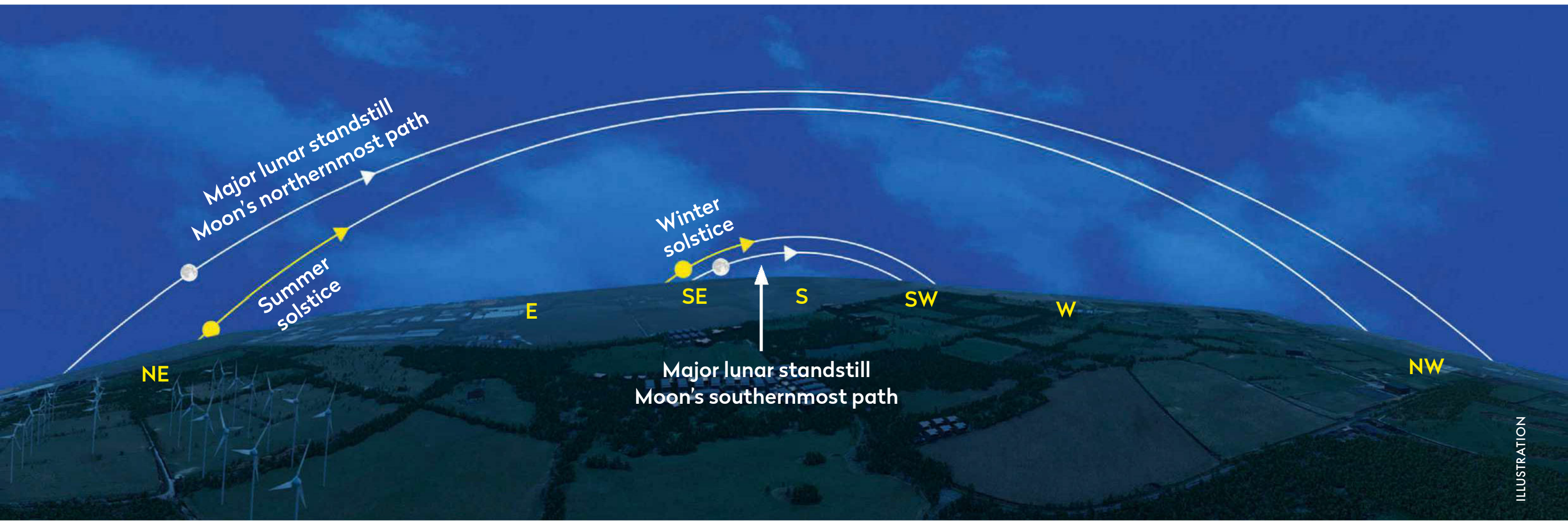
Marking time by the Moon

Over the course of a year, the Sun follows a fixed cycle of changing positions in the sky. However, the Moon's cycle is much more rapid. Our view of the Moon varies over a period of 29.5 days as it changes from a thin white crescent to a full disc and back again to a thin crescent, until disappearing for three days. Meanwhile, moonrise and moonset move from their northernmost to southernmost limits and back again in just 27 days.

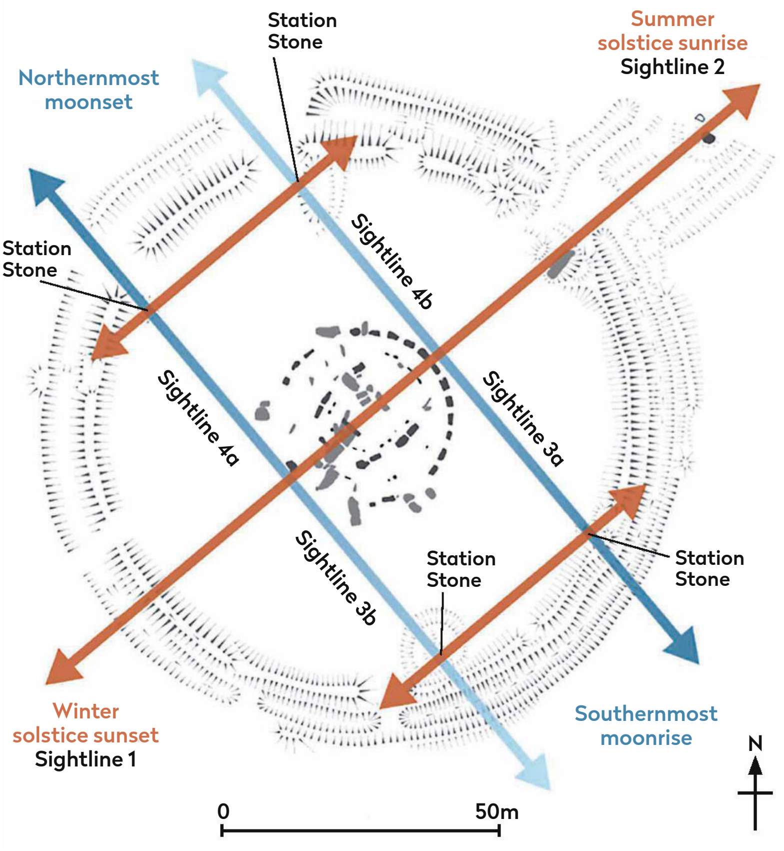
Through its phases, the Moon acts as timekeeper for societies around the globe, past and present. As well as being the basis for early calendars, in Neolithic times it was also a source of light for nighttime activities such as hunting and farming. Even today, some people still plant certain crops in the light of the full Moon, as it is thought to be beneficial to the plant's development. No doubt, the Moon had a similar significance in marking and observing the passage of time for the Neolithic people who built Stonehenge.

But the Moon also has a further cycle that is far longer. Over several years, the limits of moonrise and moonset themselves gradually change, until they reach the point where the northernmost and southernmost moonrise and moonset positions are at their maximum distance apart on the horizon. This two-year period is what is known as a major lunar standstill, or lunistice, and it only occurs every 18.6 years. Once a major standstill is reached, the distance between northernmost and southernmost moonrise and moonset can be exceptionally far apart, and it stays that way for around two years.

DAVID CLAPP/GETTY, LUNAR STANDSTILL ILLUSTRATION SOURCE: FABIO SILVA, SHARON SOUTAR, GRANTPRIVETT



▼ **At a major standstill, the Moon's rising and setting positions are their maximum distance apart on the horizon (sunrise and sunset positions at the solstices also shown)**



◀ **The solar and lunar alignments of Stonehenge, from *Stonehenge: Sighting the Sun* (2024) by Clive Ruggles and Amanda Chadburn. The rectangle made up by the four Station Stones is thought to align with moonrise and moonset during a major lunar standstill**

This is a rare celestial event and when it occurs it presents a once-in-a-generation opportunity for us at Stonehenge to explore the connection between the monument and the Moon. For much of 2024 and 2025, we are in a 'major lunar standstill season'.

Standstill at Stonehenge

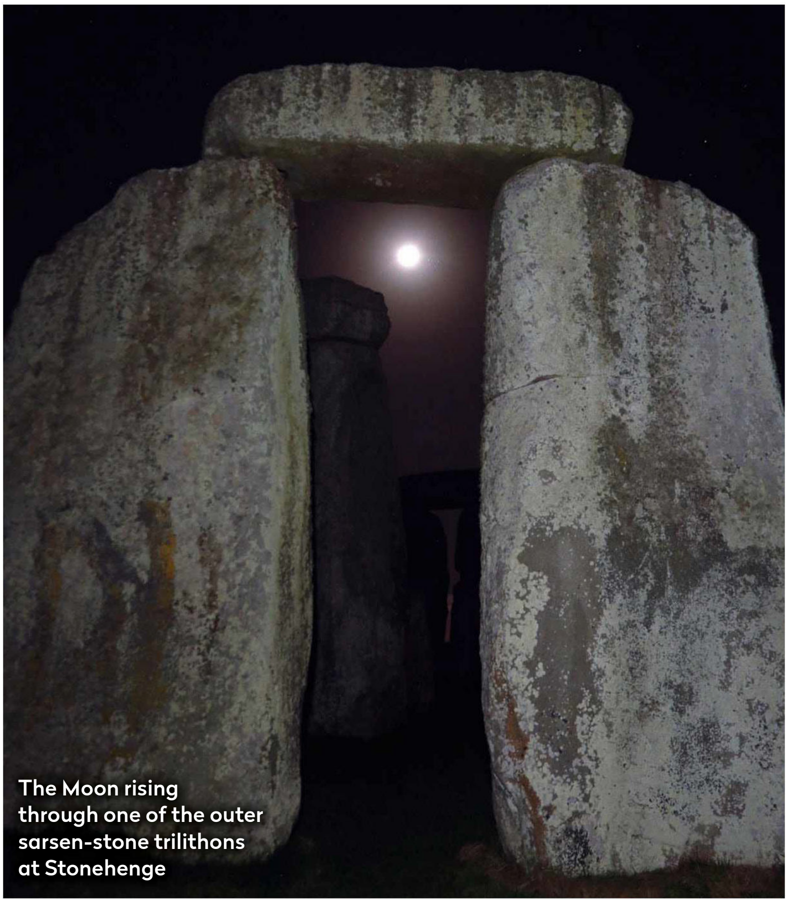
The artist and sculptor Henry Moore, in awe seeing Stonehenge for the first time in the autumnal moonlight, remarked: "Moonlight, as you know, enlarges everything, and the mysterious depths and distances made it seem enormous." The Moon transforms the way we see the world and, just over a hundred years after Moore's nocturnal visit, the Moon illuminated Stonehenge once again but now from its most southerly position, just as the summer solstice Sun set. A massive beam of light suddenly floodlit the stones and dominated the sky – the triumph of the Moon over the Sun!

The thing that is remarkable is that on a major lunar standstill, the Moon rises and sets in a place on the horizon that the Sun never reaches. Early farming communities would have tracked the movement of the Sun on the horizon across the year, so the appearance of the Moon further north and south than the extremes of the Sun may have been highly significant. Perhaps this would have been a moment when the lunar deity was stronger than the solar one.

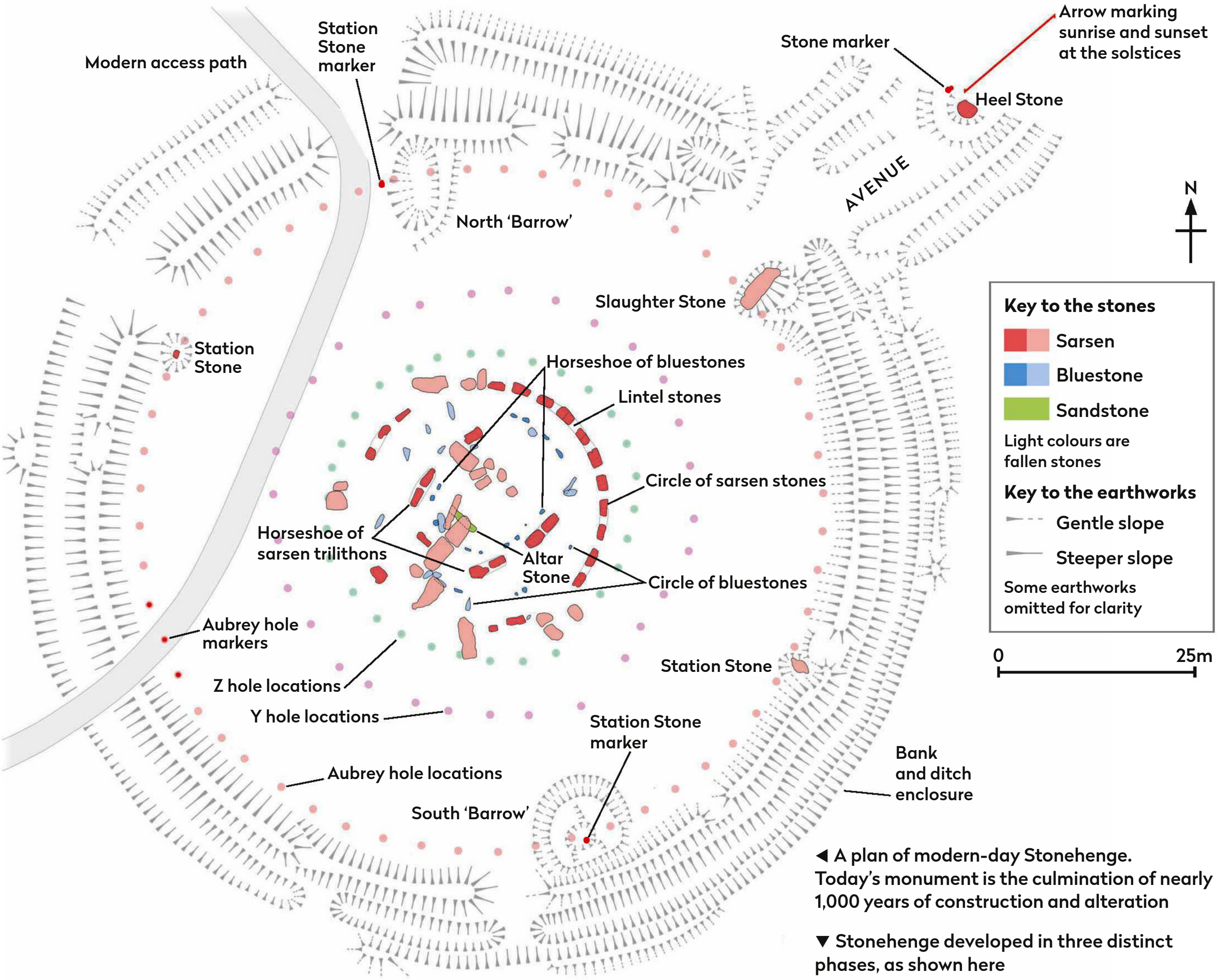
It is believed that these distinct lunar movements may have been observed during the early phase of Stonehenge, potentially influencing the later monument's design and purpose. This is the intriguing thing about Stonehenge: it is not simply one monument, but rather a special place that people transformed and added meaning to over many generations.

In its earliest phases, around 5,000 years ago, Stonehenge was a circular earthwork surrounded by a bank and ditch. This became an ancestral cemetery and people began burying cremated human remains, animal bones and grave goods for the dead in the ditch. Burials also took place in 56 regularly spaced pits called the Aubrey holes (after the antiquarian John Aubrey who first recorded them), arranged around the inner circumference of the circular earthworks. These pits may originally have housed upright timber posts or stones as part of the earliest monument at Stonehenge. Stonehenge became the largest Neolithic cremation cemetery in Britain, a place of commemoration and mourning.

This was several centuries, around 500 years, before the large stones were put up at Stonehenge. Notably, many of these cremations were concentrated in the southeast of the monument, aligning with the most southerly rising position of the Moon, where three timber posts were also set into the bank. Was there a symbolic link between the Moon and these ▶

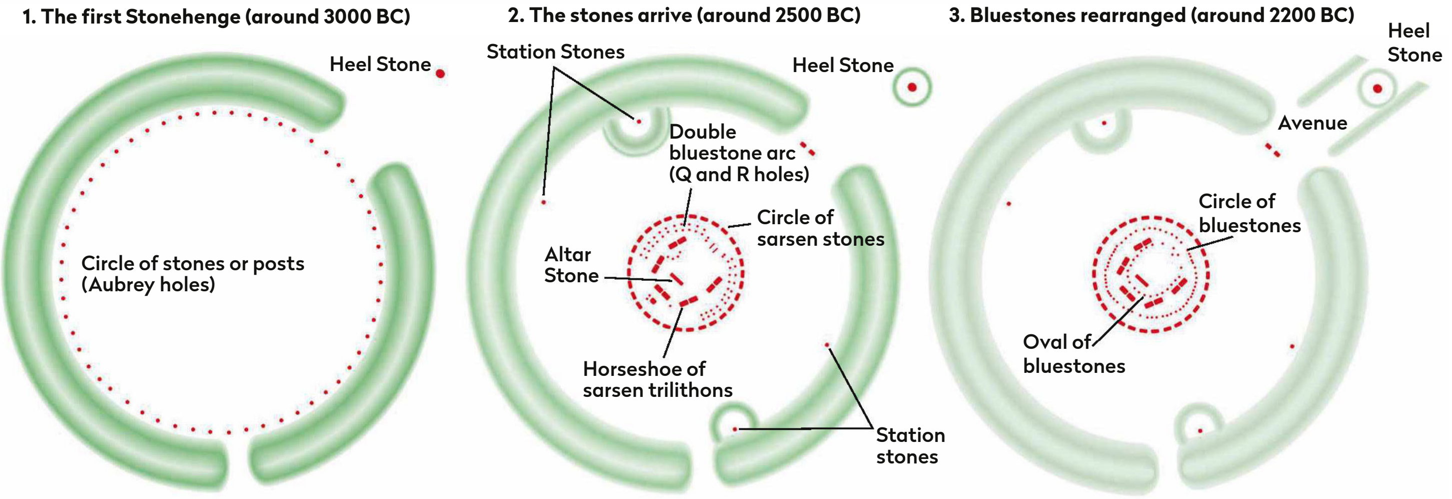


The Moon rising through one of the outer sarsen-stone trilithons at Stonehenge


Modern access path
Station Stone marker
North 'Barrow'
Stone marker
Arrow marking sunrise and sunset at the solstices
Heel Stone
AVENUE
N
Slaughter Stone
Station Stone
Horseshoe of bluestones
Lintel stones
Circle of sarsen stones
Horseshoe of sarsen trilithons
Altar Stone
Circle of bluestones
Aubrey hole markers
Z hole locations
Y hole locations
Station Stone
Station Stone marker
Aubrey hole locations
South 'Barrow'
Bank and ditch enclosure
Key to the stones
🟥 Sarsen
🟦 Bluestone
🟩 Sandstone
Light colours are fallen stones
Key to the earthworks
Gentle slope
Steeper slope
Some earthworks omitted for clarity
0
25m

◀ A plan of modern-day Stonehenge. Today's monument is the culmination of nearly 1,000 years of construction and alteration

▼ Stonehenge developed in three distinct phases, as shown here


1. The first Stonehenge (around 3000 BC)

2. The stones arrive (around 2500 BC)

3. Bluestones rearranged (around 2200 BC)

Heel Stone
Circle of stones or posts (Aubrey holes)
Station Stones
Heel Stone
Double bluestone arc (Q and R holes)
Circle of sarsen stones
Altar Stone
Horseshoe of sarsen trilithons
Station stones
Heel Stone
Avenue
Circle of bluestones
Oval of bluestones

▶ ancestral burials or the bones of the cremated dead in the earliest version of Stonehenge? It's one of the questions being investigated over the major lunar standstill.

Secrets of the stones

Around 500 years later, a massive renovation project took place at Stonehenge and the familiar form of its stone circle started to take shape. The large sarsen stones and smaller bluestones were placed into concentric circles, arranged to mark the position of the annual summer and winter solstices. Outside the stone circle were four small stones called the Station Stones, of which only two remain. These may have helped measure out the large sarsen circle when it was being built, but they also marked out a large rectangle that appears to relate to the Moon.

The long axis of this rectangle aligns in the direction of the southernmost moonrise at the major lunar standstill and (looking the opposite way) the most northerly moonset. Researchers have debated whether this was deliberate and, if so, how it was achieved and what its purpose might have been. Interestingly, the likelihood that the Station Stones

STONEHENGE DIAGRAMS: ENGLISH HERITAGEX 2, LEON WERDINGER/ALAMY STOCK PHOTO, OVERSNAP/GETTY

◀ **Chimney Rock, Colorado, where the Moon is framed by two huge sandstone spires during a major lunar standstill**

were employed to measure out the sarsen circle, five centuries after the site was first used for cremations, suggests an enduring connection between the lunar cycles and the architecture of Stonehenge.

This lunar standstill, we are seeking answers to whether Stonehenge was designed and built with the movements of the Moon in mind, and whether the possible alignments between the stones and the Moon were intentional.

Studying the stones

During the 2024–25 major lunar standstill, we have been studying these questions with Professor Clive Ruggles of Leicester University, Dr Fabio Silva of Bournemouth University and Dr Amanda Chadburn of Bournemouth University and the University of Oxford, and Dr Erica Ellington of the University of Colorado Boulder, as well as Dr Robert Massey of the Royal Astronomical Society.

On-site observations and measurements at Stonehenge during this lunar phenomenon started in spring 2024 and will continue until mid-2025. As we undertake these observations, some of the questions we are looking at are: how accurate were the lunar alignments of Stonehenge? Can these alignments still be observed today or are there modern buildings or trees blocking the view? Is there any significance to the shadows cast onto the monument during a major lunar standstill? Was the alignment with the Moon meant to be observed and, if so, how would Neolithic people have done this?

Additionally, we are working very closely with experts at Chimney Rock National Monument in Colorado, USA, as a point of comparison to the phenomenon we see at Stonehenge and other ancient British sites. Chimney Rock is an extraordinary, narrow, rocky ridge with the floor of a river valley far below, capped with two tall rock pinnacles. This ancient site has the best documented connection with moonrise during a major lunar standstill, when the Moon is dramatically framed by the rocks.

The high ridge was the site of an important Native American settlement and religious site, with ancestral Puebloan people living there between AD 925 and AD 1125. Tree ring dating of logs used in the ancient buildings shows bursts of construction or renovation that are linked to lunar standstill years, suggesting it was a place where people watched and celebrated the motions of the Moon. Today, the area still holds a deep spiritual significance for the 26 modern Pueblo and tribal communities that have cultural and traditional ties to the region, who return to this important place of cultural continuity for ceremonial and traditional purposes.

The lunar research at Stonehenge is ongoing and we hope to publish the preliminary research and insights into its Moon connections later this year. With it, we're gaining a deeper insight into what meaning the Moon might have had to the ancient builders of Stonehenge.

Jennifer Wexler is an archaeologist and the historian of prehistoric sites for English Heritage

Researchers hope to unravel the riddle of Stonehenge's lunar connections by the end of the year

A magnificent view of the Milky Way from Chile's Atacama Desert

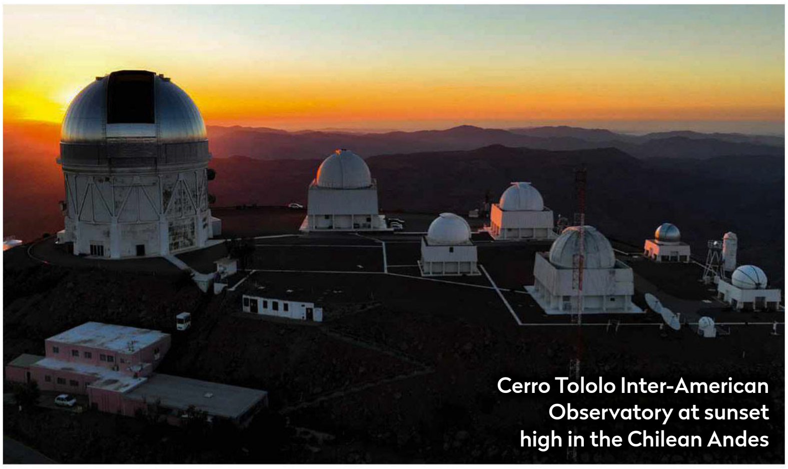
The darkest skies on Earth

In search of pristine night skies and true darkness, author **Paul Bogard** travelled 5,000 miles to northern Chile. What he found amazed him

We leave La Serena at dusk, heading east towards the stars. The 90-minute drive winds through the Elqui Valley, lush green with vineyards and home to skies so dark that international observatories on Cerro Tololo and Cerro Pachon are sited here, shining on distant mountaintops silver and rose-gold in the setting sun. Our destination is a small private observatory and our goal is to stare into the Universe.

The chance to do so is the reason I've travelled to northern Chile, where clear dry air and pristine skies have made it the world's most important area for astronomy. That I would want to travel 5,000 miles just to see what every human for most of history could see by stepping away from the campfire, or by leaning out of the back door, is testament to the never-ending spread of light pollution. Even here, as cutting-edge observatories are built to see further into space than we have ever seen before, that threat is lurking. And the stakes are high; by 2030, as much as 70 per cent of the world's astronomical infrastructure will be in northern Chile.

After a slow, winding climb into the mountains, we reach the small observatory, one of several in the area where amateur astronomers have built viewing patios to place their telescopes. Soon a van carrying a half-dozen European stargazers arrives and we make our way by muted red lights. Two telescopes await. But before we even peer through the eyepieces, it's clear we've found a night of good viewing, and a mix of Spanish, French and English begins to sound a universal human language of awe.


Cerro Tololo Inter-American Observatory at sunset high in the Chilean Andes

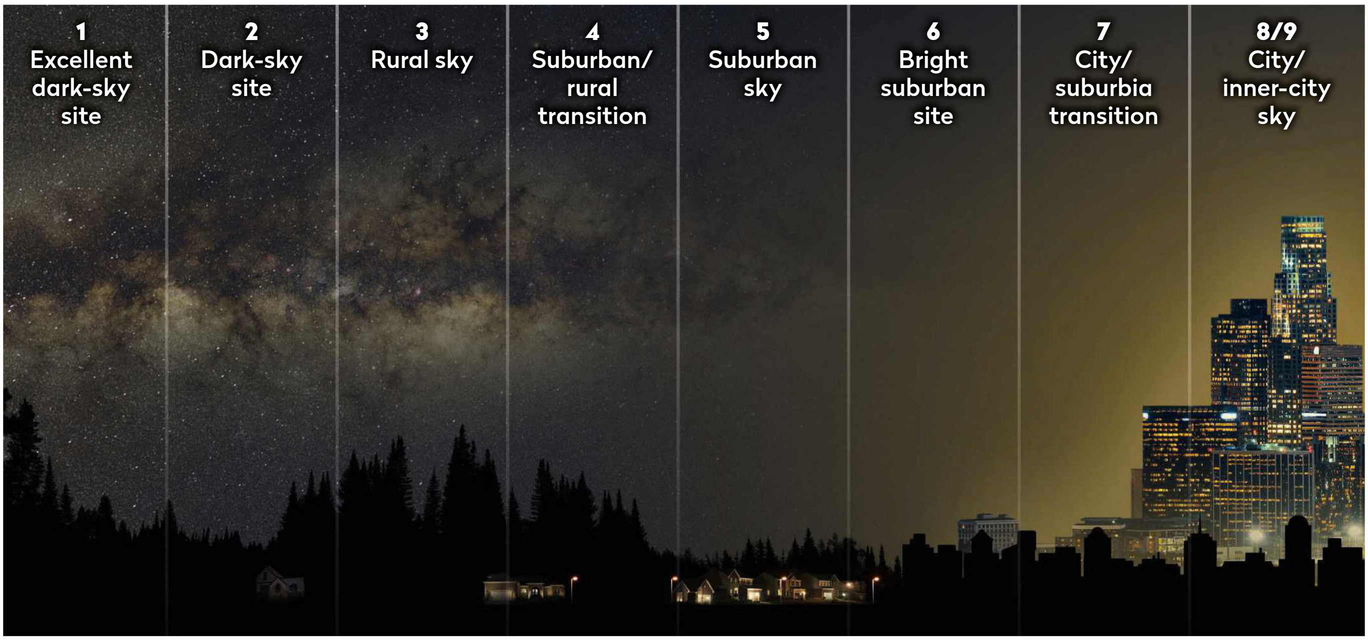
It's the brightness of the sky that first catches your eye. Venus, Jupiter and Mars are so bright your mind at first thinks "airplanes in a string", as though cued up for landing. I stare at the familiar three-star belt of Orion before realising it's upside down from what I normally see. And the Southern Cross, though the smallest of the 88 modern constellations, is immediately recognisable from the shape of its main stars. Arcing overhead, the Milky Way grows brighter as the darkness around us thickens and I think of the American poet Theodore Roethke writing "In a dark time, the eye begins to see".

Paul Bogard is an associate professor of English and the author of *The End of Night: Searching for Natural Darkness in an Age of Artificial Light*

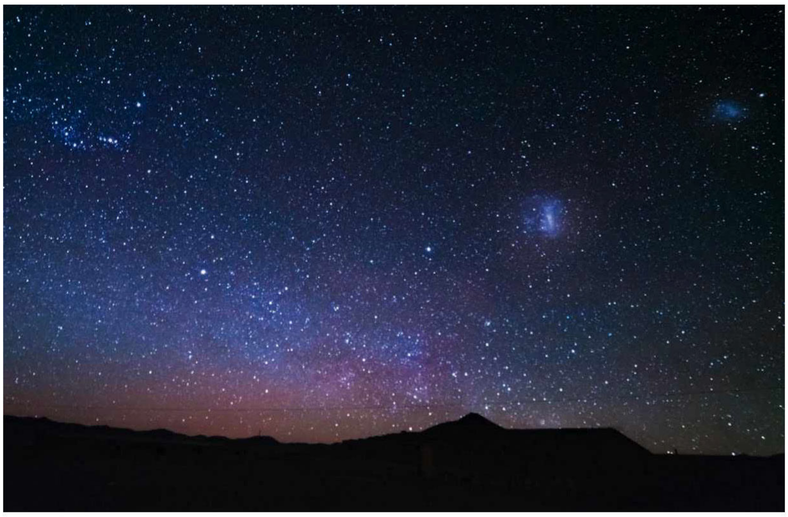
A night of endless stars

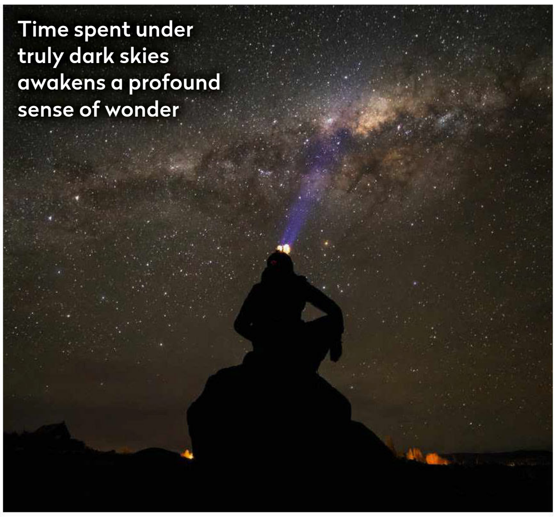
I'm surprised to realise (I'm out of practice, not used to such a sky) that the two clouds floating overhead are the Magellanic Clouds, distant galaxies only seen from the Southern Hemisphere. Actually, I'm half-right; they are clouds, just clouds of stars. "Yes, tens of thousands of millions," says our guide, and now my brain grapples with what is too big to understand.

GIULIO ERCOLANI/ALAMY STOCK PHOTO, JAVIER TORRES/GETTY, NOIRLAB/NSF/AURA/P. MARENFELD, FABIO LAMANNA/ALAMY STOCK PHOTO, NURPHOTO/GETTY



▲ The Bortle scale measures the brightness of the night sky in nine levels. Many people will never experience skies darker than level 5





Time spent under truly dark skies awakens a profound sense of wonder

▲ Orion (top left, upside down to those used to the Northern Hemisphere view) and the Magellanic Clouds seen from Andean skies untouched by light pollution

But that's okay. Too often we think of feeling overwhelmed as negative, but under a night sky I welcome the feeling and the appreciation that we exist in a Universe where this exists too.

Then to the telescopes, and the beauty intensifies. Saturn on its side, the rings a shining sword stuck through the planet's ball. The scope turns, revealing Toucan 47, a cluster of millions of stars, and one after another we lose our breath. With the naked eye, the sight is just a smudge in this southern sky, but through the telescope the beauty blooms in uncountable numbers.

Moments of contemplation

Earlier in the day, at Cerro Tololo, I asked an astronomer what 'good' does it do to look further and further into space. He nodded. "On the hierarchy of needs, you have food and water and shelter, but life isn't only those basic needs. There's also a more spiritual or soulful desire to look out there. And with the night sky, trying to understand specific things – like what is a star? What's the Sun? What is a supernova? – through these small explorations, we're trying to answer these big questions, trying to get some satisfaction. I think that there's a need to understand our position in the Universe very deep in our brains and in our hearts."

So many of us have lost the chance for such an experience. No one in a city or suburb will see a night sky this dark. On the Bortle scale, where 9 marks our brightest places and 1 our darkest, most North Americans and Europeans will never experience anything darker than level 5.

But for now, this is one of the darkest skies I have ever seen, a night I will not forget. To stare into the sky, the numbers and distances beyond our brains' reach – this inability to grasp is part of what makes the experience so valuable, a reminder we perhaps could use more often: we are not in control of everything, our worries are small, our lives brief. All the more reason to savour what we can see while we are here, now.

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16-PAGE CENTRE PULLOUT

BBC Sky at Night MAGAZINE

The Sky Guide

JUNE 2025

PETE LAWRENCE

NOCTILUCENT CLOUDS IN 2025

There were several impressive NLC displays last summer. What does the 2025 season have in store?

ANTARES CHALLENGE

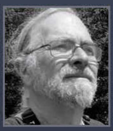
Can you spot the red supergiant's sidekick?

EXPLORE THE SERPENT'S TAIL

Six deep-sky treasures to find near Serpens Cauda

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four



Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- Moon, Saturn and Neptune conjunction
- Mars near Regulus
- Lunar sea Mare Orientale
- Asteroid 89 Julia

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

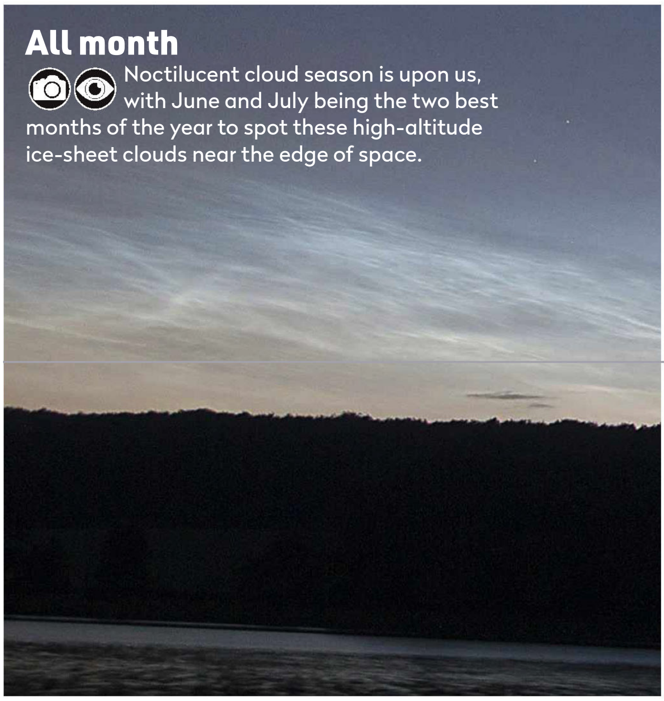
For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

JUNE HIGHLIGHTS

Your guide to the night sky this month

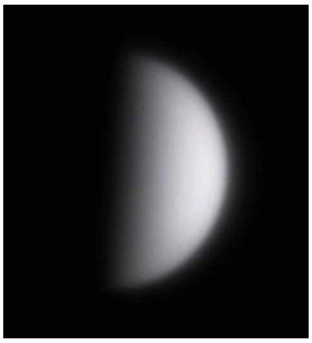
All month

Noctilucent cloud season is upon us, with June and July being the two best months of the year to spot these high-altitude ice-sheet clouds near the edge of space.



Sunday ▶

1 Morning planet Venus reaches greatest western elongation. This morning, it will appear separated from the Sun by 45.9°. In theory, the planet should be at 50% illumination, although its phase anomaly suggests this may be a few days late.



Wednesday

4 The effect known as Plato's Hook is visible on this evening's Moon, best around 23:00 BST (22:00 UT). At this time, a rim peak shadow forms inside crater Plato that some have described as curved.

Thursday

5 The minor planet 5 Astraea reaches opposition, when it can be seen mimicking a mag. +10.6 star among the stars of Ophiuchus.

Monday ▶

16 In the run-up to midnight and as it approaches setting, mag. +1.4 Mars sits just 0.8° north of mag. +1.3 Regulus (Alpha (α) Leonis).

Thursday ▶

19 Saturn lies 2.0° south of this morning's last quarter Moon at (02:25 BST) 01:25 UT, with Neptune between them 1.3° southwest of the Moon's centre.

Saturday ▶

21 At 03:41 BST (02:41 UT), the Sun reaches its most northerly declination against the background stars, a point in time known as a solstice. In the Northern Hemisphere, it's the summer solstice; in the Southern Hemisphere, the winter solstice.

Sunday

22 There's a lovely conjunction between the 15%-lit waning crescent Moon and mag. –4.1 Venus today, low above the east-northeast horizon around 03:30 BST (02:30 UT).

Family stargazing

The Moon illusion is when the fuller Moon phases appear near the horizon, making the Moon look much larger than it is. This month, the full Moon appears really low for ages, hardly gathering height at all on the evening of 10/11 June. Ask your young observer(s) to look at the Moon and commit its size to memory. Turn them away from the Moon, then ask them to show the Moon's size using thumb and forefinger at arm's length. Keeping their arms outstretched, get them to turn around and line up their estimates with the real Moon. **www.bbc.co.uk/cbeebies/shows/stargazing**

Friday

27 Rising around 07:10 BST (06:10 UT), Mercury is 2.0° south of the 4%-lit waxing crescent Moon, a tricky daylight sight. In the evening, the separation is 7.3°, the Moon now 7% lit. Spot them around 22:30 BST (21:30 UT) low above the west-northwest horizon.

Sunday

29 Locate the Moon low above the western horizon after sunset, say around 23:00 BST (22:00 UT), and you'll find mag. +1.5 Mars slightly less than 2° to the east of it. Mag. +1.3 Regulus is 5.1° west-northwest of the Moon at this time.

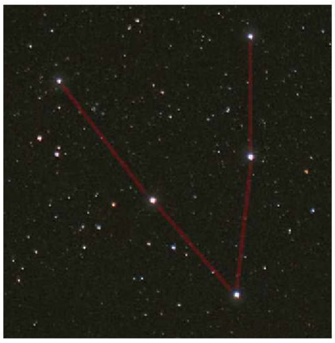
PETE LAWRENCE X 8

Monday 2

With dark skies in short supply, early summer is graced by the beautiful red supergiant Antares (Alpha (α) Scorpii). Its tricky-to-see companion is our Challenge target this month (see page 55). Antares is due south around 01:00 BST (00:00 UT) at the start of June.

Tuesday ▶ 3

A less well-known asterism in the summer sky is Poniatowski's Bull, a V-shaped pattern off the northeastern shoulder of Ophiuchus formed from 66, 67, 68, 70 and 73 Ophiuchi. The pattern is just east of south, about 40° up, at around 01:00 BST (00:00 UT).



Tuesday 10

This evening and into the morning of 11 June, the full Moon is very low when due south. This is near a 'major lunar standstill', the lowest Moon in an 18.6-year lunar cycle. It's also a perfect chance to experience the Moon illusion, which makes the low full Moon appear much larger than it really is. Turn to page 76 for details of how to capture it.

Sunday 15

Libration starts to favour this month's Moonwatch target, Mare Orientale and its surroundings (see page 52).

Friday 20

This month's Deep-Sky Tour on page 56 looks at objects near Serpens Cauda, the Serpent's Tail. The tour is made all the more challenging due to the lack of true darkness. Have a go and see how you get on.

Monday ▶ 23

A tricky observation at best, this morning's 7%-lit waning crescent Moon will clip the southernmost stars in the Pleiades open cluster. The event will be hampered by bright twilight.

Monday 30

Not the easiest spot in bright twilight, but mag. +0.7 Saturn and mag. +7.9 Neptune are less than a degree apart this morning. Catch them 10° up above the east-southeast horizon at 02:00 BST (01:00 UT).

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)

Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly Objects marked with this icon are perfect for showing to children

Naked eye Allow 20 minutes for your eyes to become dark-adapted

Photo opp Use a CCD, planetary camera or standard DSLR

Binoculars 10x50 recommended

Small/ medium scope Reflector/SCT under 6 inches, refractor under 4 inches

Large scope Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

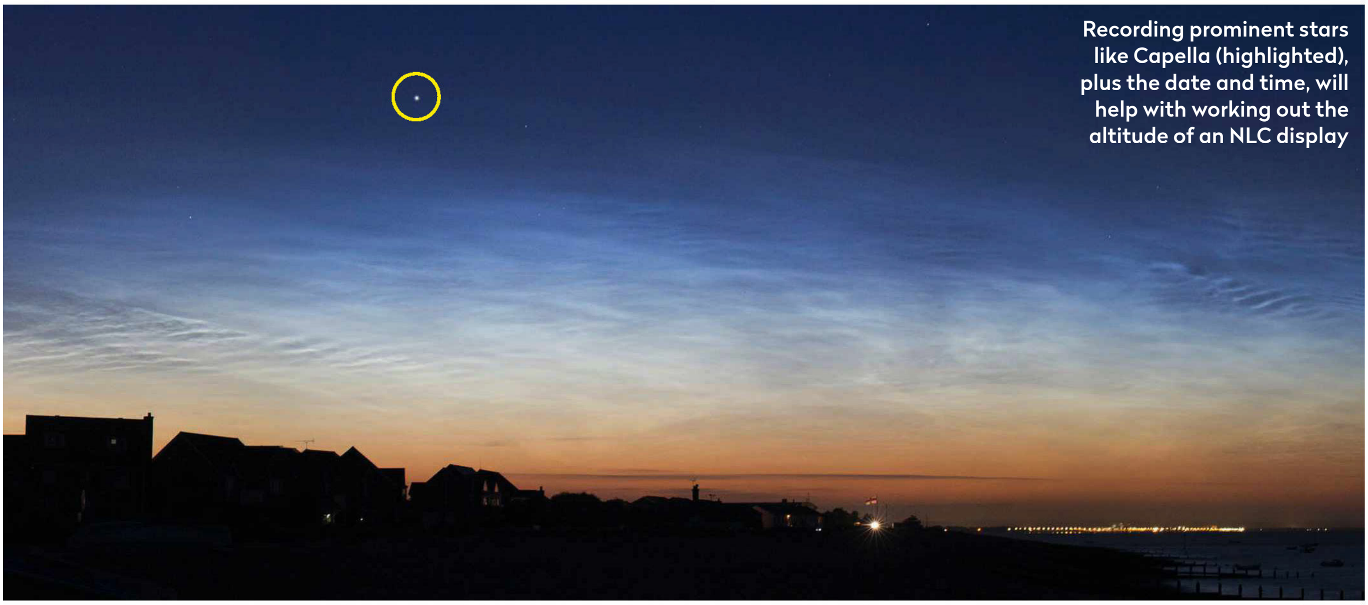
If you're new to astronomy, you'll find two essential reads on our website. Visit **bit.ly/stargazing-top-tips** to learn how to stargaze in 12 easy steps and **bit.ly/choose-first-telescope** for advice on choosing your first scope

THE BIG THREE The top sights to observe or image this month

DON'T MISS

Noctilucent clouds for 2025

BEST TIME TO SEE: All month



Recording prominent stars like Capella (highlighted), plus the date and time, will help with working out the altitude of an NLC display

For those of us in the Northern Hemisphere, the lack of true darkness in the middle of the year doesn't make astronomy that easy to do. The planets are good at cutting through slightly brighter skies, but they aren't currently well placed. On top of that, in the weeks around the solstice, the period of night is fleetingly short.

Fortunately, there's an upside to this, as the period between late May and early August is when noctilucent clouds (NLCs) may be seen. These high-altitude ice-sheet clouds form at a height of around 82km, but their presence isn't guaranteed. They become visible during these months because this is when the region within the mesosphere in which they occur dips in temperature enough for the constituent ice crystals to form.

Another important factor is the position of the Sun relative to the horizon. For NLCs to become visible, the sky has to darken sufficiently and the angle has to be optimal for them to reflect sunlight to our eyes. This situation typically occurs when the Sun is 6°–16° beneath the horizon, a condition that is achieved 90–120 minutes after sunset or a similar time before sunrise from the UK.

During the period around the solstice, the visibility requirements may persist all night long and extensive NLC displays can be seen in the late evening low above the northwest horizon, tracking through north in the middle of the night and slowly fading from view low above the northeast horizon in the pre-dawn period.

NLC displays frequently exhibit fine, repeating herringbone patterns, as seen here

NLCs have an ethereal quality to them, typically appearing blueish in colour and very finely detailed, with networks of delicate tendrils or patches displaying intricate herringbone patterns. Observing them is easy, as all you need is your eyes. They are often bright enough for phone cameras to record too, making them an ideal target to look out for on short summer nights.

There's no guarantee of a display happening on any particular night; you just have to be vigilant and keep checking. Many online groups have appeared over recent years that report when NLC events are visible. If you see a display and want to report it, the bare minimum information that is required is date, time and location. A description of the display is also useful, as is an estimate as to how high it extends above the horizon. Photographs are very useful of course, but again, to maximise their potential, include the date, time and location with each one.

ALL PICTURES: PETE LAWRENCE

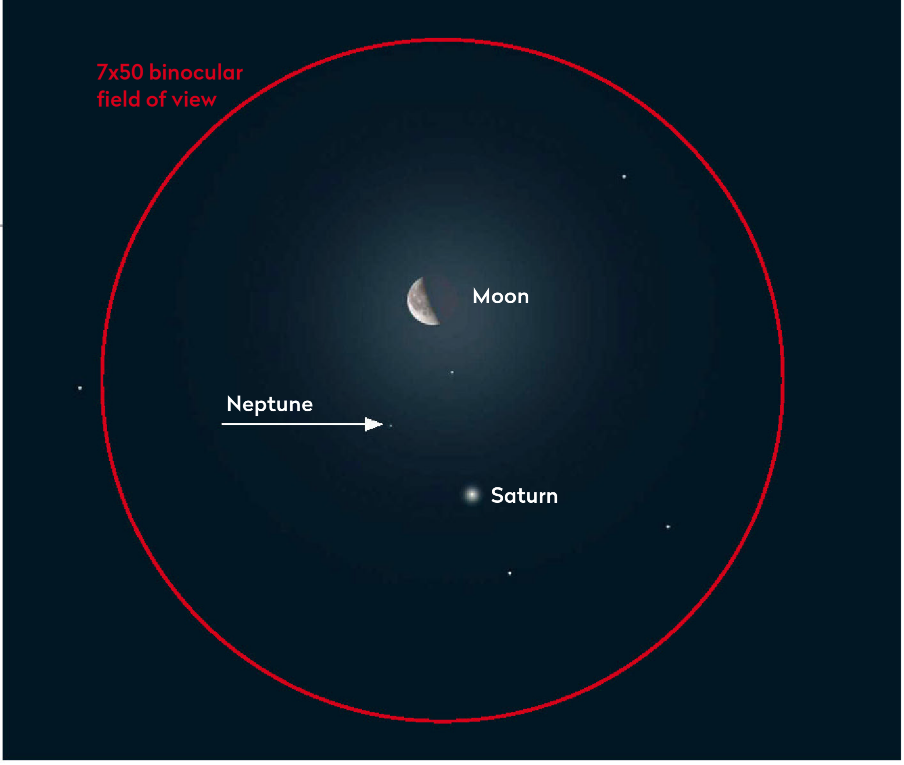
Saturn, Neptune and the Moon

BEST TIME TO SEE: 18 and 19 June, from 02:00 BST (01:00 UT)

Saturn currently appears near Neptune, the two separated by around 1°. Saturn shines at magnitude +0.7 mid-month but the pre-sunrise twilight is bright, making spotting the planet that bit harder. Neptune is much dimmer at mag. +7.9 and could be a struggle even for binoculars. A small telescope at low magnification should be able to grab both.

On the morning of 18 June, using binoculars, centre the view on Saturn. Neptune should be visible at the 10 o'clock position from Saturn, slightly less than halfway from Saturn to the edge of the field of view using typical binoculars. Be aware that the combination of bright sky, low altitude and potentially hazy weather may hide Neptune from view. If this is the case, this is the perfect time to break out a telescope if you have one. Looking at the Moon first, you'll need a low-power eyepiece that can ideally fit 2+ Moons across the field of view. If not, don't worry; simply estimate how large the Moon looks through the eyepiece (this being 0.5°) and use this information to locate Neptune.

On the morning of 19 June, the Moon will be 47%-lit or just less than last quarter phase. On this morning, it sits 2° north-northwest of Saturn, with Neptune located slightly east (left) of the mid-point between both the Moon and Saturn. Don't get confused by the mag. +6.3 star located 0.8° south-southeast of the Moon's centre!



▲ **Saturn and Neptune are sitting near one another this month and will be joined by the last quarter Moon in the early morning on 19 June. This is the view at 02:00 BST (01:00 UT)**

Mars near Regulus

BEST TIME TO SEE: 15–18 June, from 23:00 BST (22:00 UT)

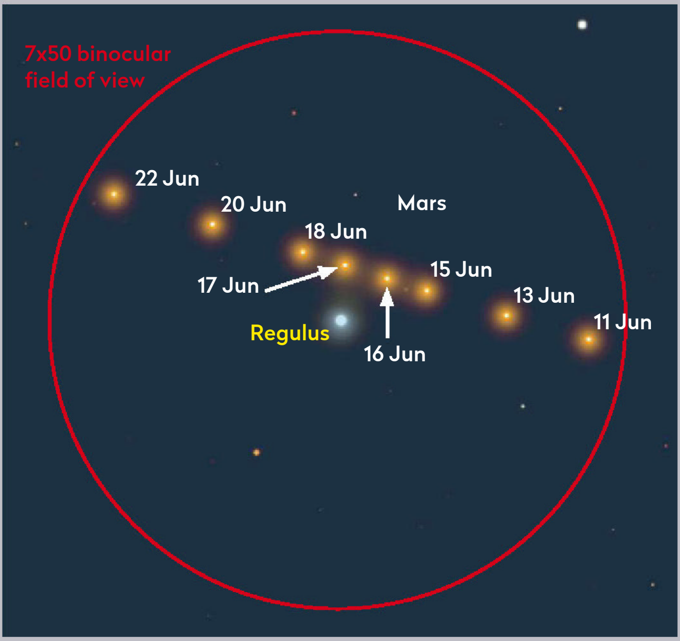
Regulus (Alpha (α) Leonis) sits close to the ecliptic, the Sun's apparent path against the stars, which represents the projection of the Earth's orbital plane into space. The major Solar System bodies also move relatively close to the ecliptic and from time to time these bodies have close encounters with Regulus.

This is the case during June when Mars passes close to the star. The best viewing times will be in the darkening evening twilight from 23:00 BST (22:00 UT) between 15 and 18 June, when both objects are visible about 15° above the western horizon.

At the time of their meeting, Mars will be shining at mag. +1.4, a fraction dimmer than Regulus's mag. +1.3. On the evening of 15 June, the two objects are separated by 1.2°. On 16 June, the gap closes to 52 arcminutes, dropping to 45 arcminutes on 17 June.

Close though this will appear, remember you could still fit 1.5 full Moons between them. On the evening of 18 June, the gap reopens, with Mars and Regulus now separated by 1°.

Finally, on the evening of 29 June, a 22%-lit waxing crescent Moon invades the show. Mars will have moved significantly further east on this date, now sitting 7° from Regulus. The Moon will sit between the two planets, 2° to the west of Mars.



▲ **To see Mars make a close pass of the star Regulus, look to the west at about 23:00 BST (22:00 UT) in mid-June**

THE PLANETS Our celestial neighbourhood in June

PICK OF THE MONTH

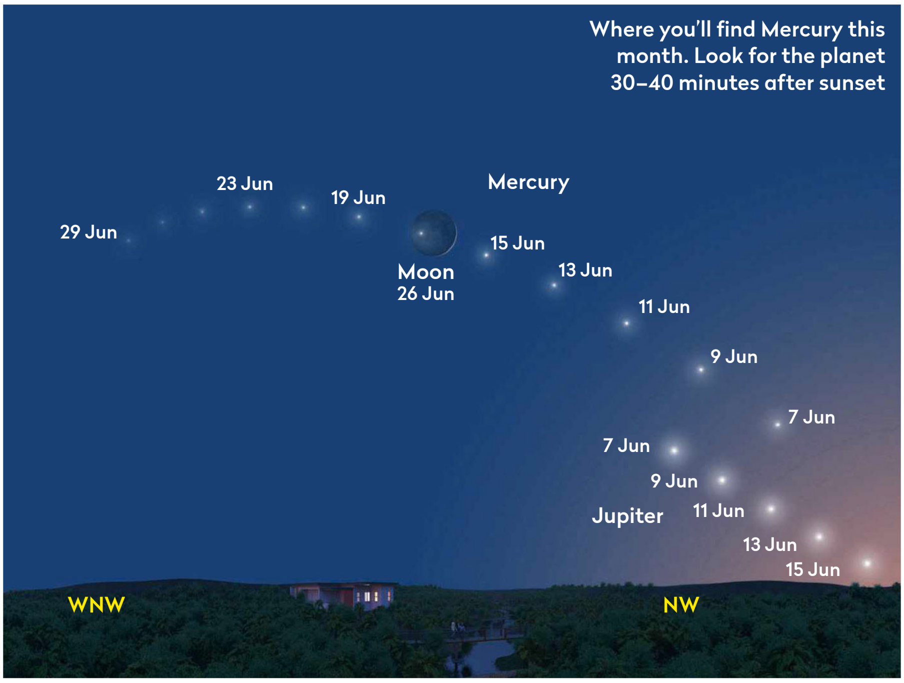
Mercury

Best time to see: 15 June, from 40 minutes after sunset
Altitude: 5° (low)
Location: Gemini
Direction: Northwest
Features: Phase, surface features
Recommended equipment: 100mm or larger

Remember the glory days at the end of 2024 and beginning of 2025 when there were planets everywhere? Well, that's not the case currently, with some very close to the Sun and others compromised by the bright skies of June. Little Mercury meanwhile continues to do what it does best, flitting back and forth on either side of the Sun. This month finds it on the eastern or evening side of the Sun, a potential target if you have a good flat northwestern horizon.

At the start of June, Mercury isn't that well placed, located just 3.5° from the Sun and setting shortly after sunset on the 1st. Things improve with each passing day, but it's not until the middle of the month that the planet becomes readily viable.

On 8 June, mag. –1.1 Mercury sits just 2° from mag. –1.8 Jupiter but, with the pair setting about one hour after sunset, spotting them together isn't going to be that easy. On this date, Mercury sits due north of Jupiter. By 15 June, Mercury will have faded to magnitude –0.5, but it will be sufficiently far separated from the Sun to set 90 minutes after sunset and this, coupled with it holding onto some of its former brightness, should make it viable.


Where you'll find Mercury this month. Look for the planet 30–40 minutes after sunset
23 Jun
19 Jun
Mercury
29 Jun
15 Jun
Moon
26 Jun
13 Jun
11 Jun
9 Jun
7 Jun
7 Jun
9 Jun
Jupiter
11 Jun
13 Jun
15 Jun
WNW
NW

Wait for the Sun to set, then start to look for it using binoculars around 40 minutes after sunset. If you can spot it using a telescope, on 15 June Mercury shows a 5-arcsecond disc with a gibbous 74%-lit phase.

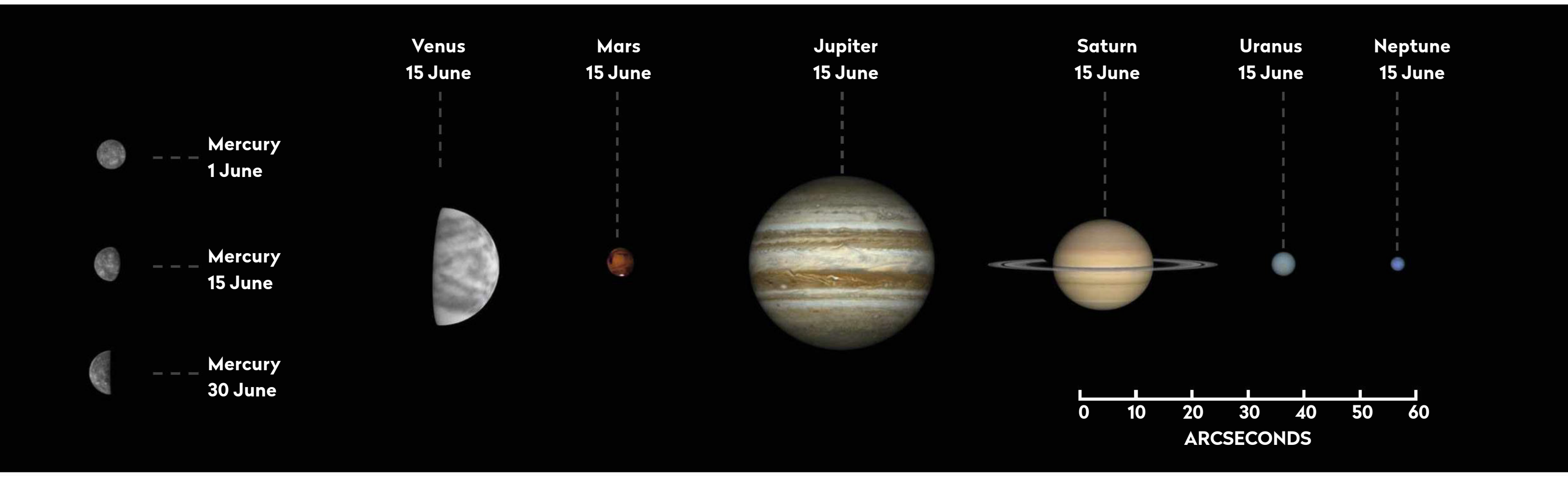
Jupiter meeting Mercury in March 2023, when evening twilight impacted the view

As the month progresses, Mercury continues to distance itself from the Sun but also continues to lose brightness. On 26 and 27 June, a thin waxing crescent Moon moves from the right to left of the mag. +0.2 planet.

PETE LAWRENCE X 2

The planets in June

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope


Venus
15 June
Mars
15 June
Jupiter
15 June
Saturn
15 June
Uranus
15 June
Neptune
15 June
Mercury
1 June
Mercury
15 June
Mercury
30 June
0
10
20
30
40
50
60
ARCSECONDS

Venus

Best time to see: 30 June, 50 minutes before sunrise
Altitude: 11°
Location: Taurus
Direction: East

Morning planet Venus rises just before 03:30 BST (02:30 UT) on 1 June. Sunrise is just before 05:00 BST (04:00 UT), providing a 40-minute or so window to try to catch the mag. –4.2 planet. On 1 June, Venus reaches greatest western elongation, separated from the Sun by 45.9°. Through a telescope on this date, Venus appears 23 arcseconds across and 50% lit. However, according to the phase anomaly, the observed 50% phase is supposed to be late by a few days for morning appearances.

On 22 June, a 15%-lit waning crescent Moon lies 5.9° north of Venus, a lovely sight given clear skies. By the end of the month, Venus rises nearly 2.5 hours before the Sun, shining at mag. –4.0 but shrinks in apparent diameter to 17 arcseconds, with a phase of 63%.

Mars

Best time to see: 1 June, from 23:00 BST (22:00 UT)
Altitude: 22°
Location: Leo
Direction: West

Mars is in the evening sky, a dimming planet tracking east through Leo throughout June. On 1 June, it shines at mag. +1.3 and is located 6° west of a 37%-lit waxing crescent Moon. Mars is now quite distant from Earth and its apparent diameter through the eyepiece of a telescope is just 5 arcseconds.

Between 15 and 18 June, Mars makes a relatively close pass of Regulus (Alpha (α) Leonis), separated from the star by 52 arcminutes on 16 June, and 45 arcminutes on 17 June. Turn to page 47 for more details on this encounter.

On 29 June at low altitude above the western horizon, a 22%-lit waxing crescent Moon appears 1.7° to the west of Mars at 23:30 BST (22:30 UT).

Jupiter

Best time to see: 1 June, from 30 minutes after sunset
Altitude: 4° (very low)
Location: Taurus
Direction: Northwest

Jupiter is a tricky planet to spot this month, reaching solar conjunction on 24 June. On 8 June, the planet sits 2° from Mercury in the post-sunset sky.

Saturn

Best time to see: 30 June, 02:40 BST (01:40 UT)
Altitude: 15°
Location: Pisces
Direction: East-southeast

Saturn is poorly positioned in the morning sky at the start of the month, but does improve a little towards the end of June. Shining at mag. +0.8 on 1 June, Saturn brightens to +0.7 by the end of the month. On 19 June at 02:50 BST (01:50 UT), at an altitude of 11°, a 46%-lit waning crescent Moon sits 2° north of Saturn, with mag. +7.9 Neptune between them. You can find more details about this on page 47.

Uranus

Not visible

Neptune

Not really a viable target this month, mag. +7.9 Neptune is located near Saturn.

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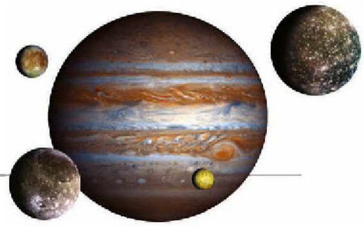
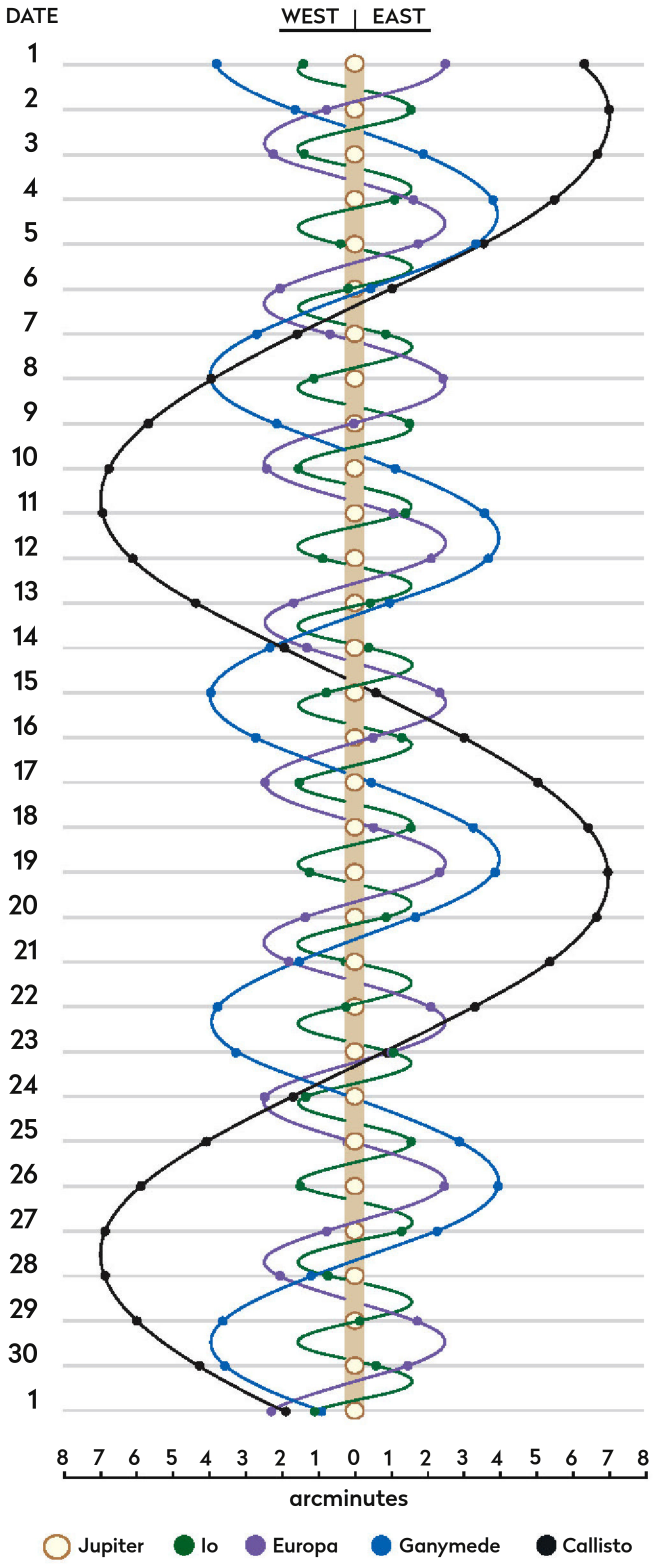


JUPITER'S MOONS: JUNE

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – JUNE

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

Arcturus	STAR NAME
PERSEUS	CONSTELLATION NAME
⬭	GALAXY
◌ ⁘	OPEN CLUSTER
⊕	GLOBULAR CLUSTER
☼	PLANETARY NEBULA
□	DIFFUSE NEBULOSITY
●	DOUBLE STAR
○	VARIABLE STAR
◐	THE MOON, SHOWING PHASE
☄	COMET TRACK
●	ASTEROID TRACK
⋯	STAR-HOPPING PATH
△	METEOR RADIANT
Circlet	ASTERISM
🪐	PLANET
☼	QUASAR

STAR BRIGHTNESS:

●	MAG. 0 & BRIGHTER
●	MAG. +1
•	MAG. +2
•	MAG. +3
·	MAG. +4 & FAINTER
5° N E W S	COMPASS AND FIELD OF VIEW
	MILKY WAY

CHART: PETE LAWRENCE

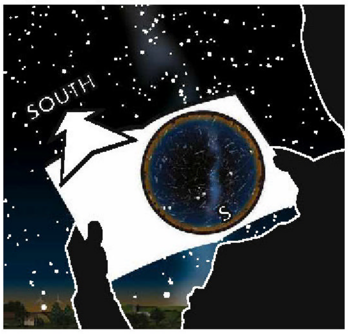
When to use this chart

1 June at 01:00 BST
15 June at 00:00 BST
30 June at 23:00 BST

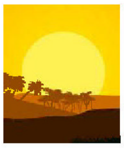
On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in June*



Date	Sunrise	Sunset
1 Jun 2025	04:47 BST	21:28 BST
11 Jun 2025	04:41 BST	21:38 BST
21 Jun 2025	04:41 BST	21:42 BST
1 Jul 2025	04:45 BST	21:41 BST

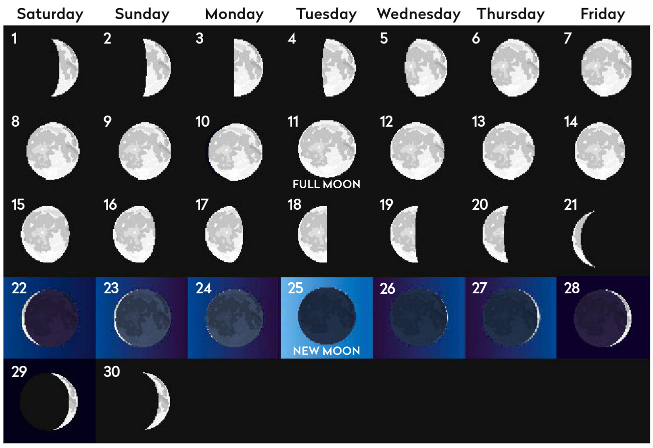
Moonrise in June*

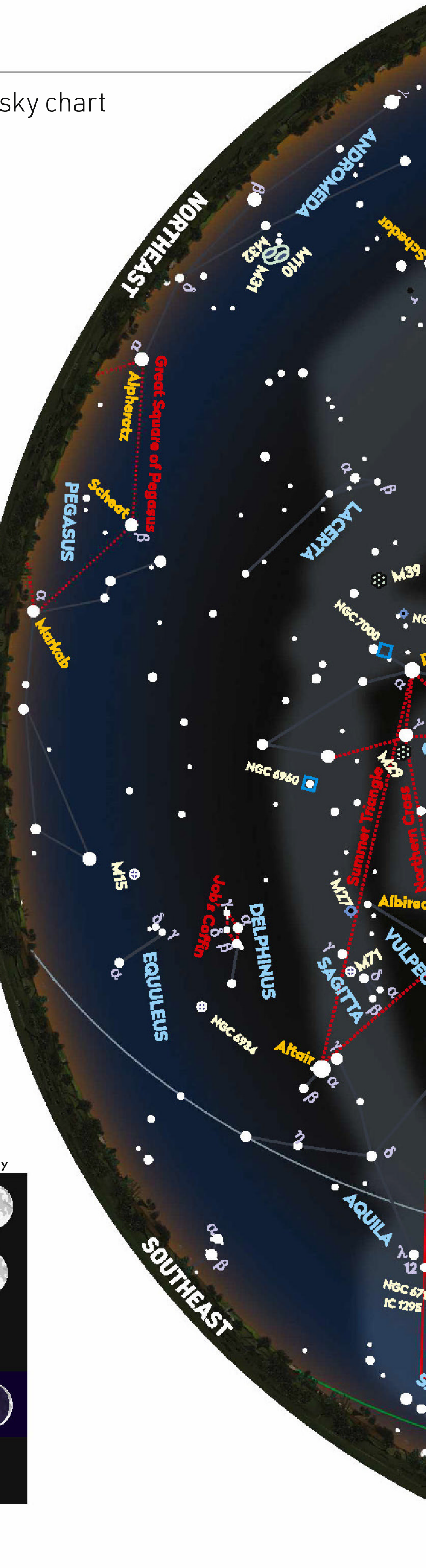
Moonrise times

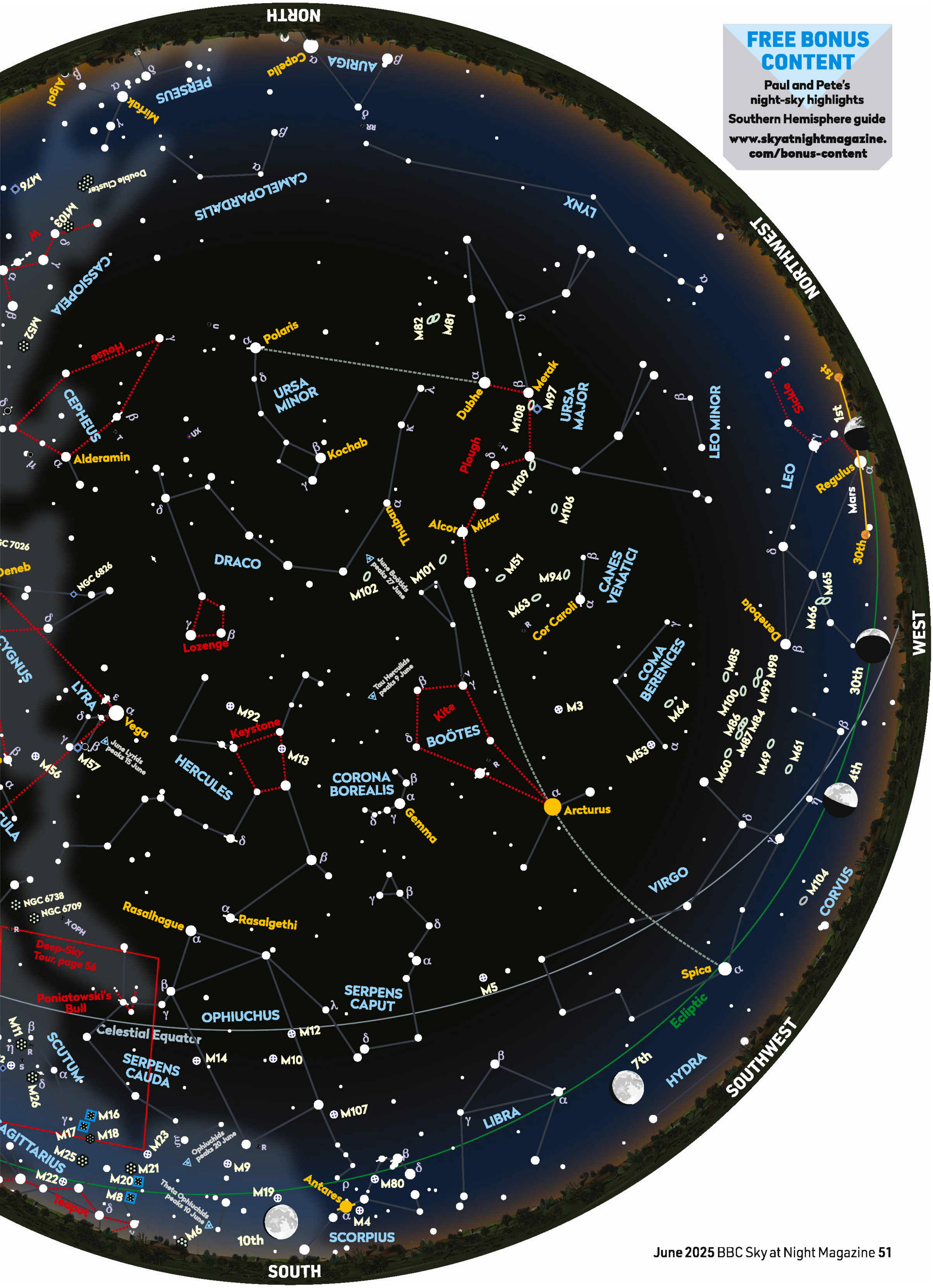
1 Jun 2025, 10:27 BST
5 Jun 2025, 15:31 BST
9 Jun 2025, 20:31 BST
13 Jun 2025, --:-- BST
17 Jun 2025, 00:57 BST
21 Jun 2025, 01:38 BST
25 Jun 2025, 03:47 BST
29 Jun 2025, 09:26 BST

*Times correct for the centre of the UK

Lunar phases in June




NORTHEAST
ANDROMEDA
M32
M31
M110
Schedar
Alpheratz
Great Square of Pegasus
Scheat
PEGASUS
LACERTA
M39
NGC 7000
Markab
EAST
NGC 6960
M29
Summer Triangle
Northern Cross
M15
Job's Coffin
DELPHINUS
EQUULEUS
M27
Albireo
SAGITTA
M71
NGC 6934
Altair
AQUILA
SOUTHEAST
IC 1295


NORTH
SOUTH
WEST
NORTHWEST
SOUTHWEST
Capella
AURIGA
PERSEUS
Algol
Mirfak
RR
CAMELOPARDALIS
Double Cluster
M76
M103
W
CASSIOPEIA
M52
LYNX
Polaris
House
CEPHEUS
Alderamin
URSA MINOR
Kochab
M82
M81
Dubhe
Merak
M97
M108
URSA MAJOR
Plough
M109
LEO MINOR
Sickle
1st
Regulus
Mars
30th
LEO
M106
Alcor
Mizar
Thuban
DRACO
June Boötids peaks 27 June
M102
M101
M51
M94
M63
Cor Caroli
CANES VENATICI
M65
M66
Denebola
NGC 7026
Deneb
NGC 6826
CYGNUS
Lozenge
LYRA
Vega
June Lyrids peaks 15 June
M56
M57
Tau Herculids peaks 9 June
M92
Keystone
M13
HERCULES
Kite
BOÖTES
M3
COMA BERENICES
M64
M85
M100
M98
M99
M86
M84
M87
M60
M49
M61
M53
CORONA BOREALIS
Gemma
Arcturus
4th
VIRGO
M104
CORVUS
NGC 6738
NGC 6709
X OPH
Rasalhague
Rasalgethi
Deep-Sky Tour, page 56
Poniatowski's Bull
Celestial Equator
OPHIUCHUS
SERPENS CAPUT
M5
Spica
Ecliptic
M12
M14
M10
M11
SCUTUM
SERPENS CAUDA
M26
M16
M17
M18
M23
Ophiuchids peaks 20 June
M107
LIBRA
7th
HYDRA
SAGITTARIUS
M25
M21
M9
M20
M22
M8
Theta Ophiuchids peaks 10 June
M19
M80
Antares
M4
Teapot
M6
10th
SCORPIUS

FREE BONUS CONTENT

Paul and Pete's night-sky highlights

Southern Hemisphere guide

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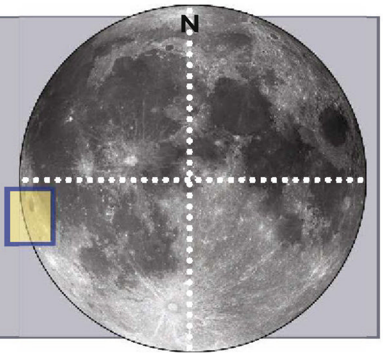
MOONWATCH June's top lunar feature to observe

Mare Orientale

Type: Lunar sea
Size: 330km
Longitude/latitude: 94.7° W, 19.9° S
Age: 3.8–3.9 billion years
Best time to see: Determined by libration and phase (15–23 June and 11–20 July)
Minimum equipment: 10x binoculars



> **Three rather challenging craters adorn the sea. Be under no illusion – these are tough!**

Mare Orientale is a large sea partly visible from Earth on the Moon's west-southwest edge. With a diameter of 330km, it's the eastern portions of its floor that extend over the Moon's edge towards Earth. The Moon is tidally locked to our planet, rotating once on its axis in the same time it takes to complete an orbit around Earth. In theory, this means we should always see the same hemisphere of the Moon. While generally true, the Moon's elliptical and slightly tilted orbit does allow us to see a little extra around the Moon's edge over time, an effect described by the term 'libration'.

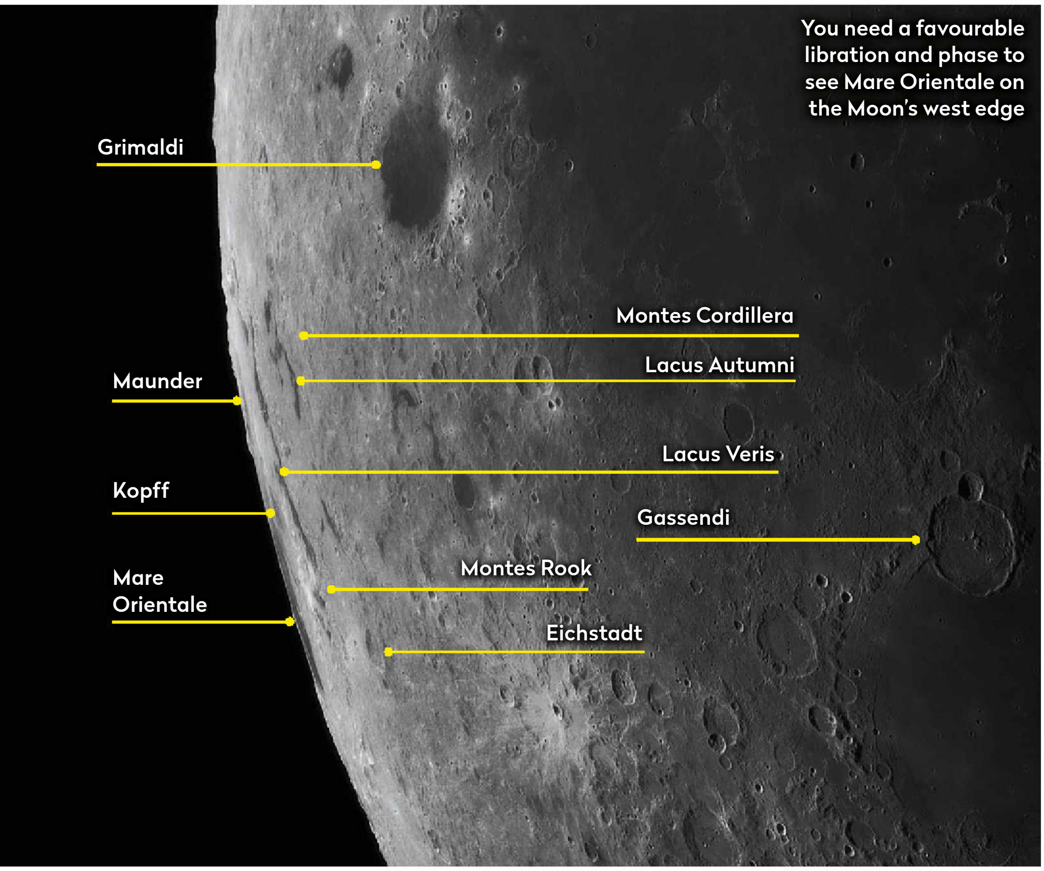
Favourable libration brings an area closer to the centre of the Moon's disc as seen from Earth. This isn't the full story though, and for us to observe an edge feature under favourable libration, lighting has to be good too – the phase must be such that it is illuminated. Also, when the terminator is nearby, lighting becomes oblique, causing dramatic shadows to appear. In the case of Mare Orientale, this is a definite bonus, but not the be-all and end-all because the mare and its surrounding area have plenty of albedo variation too, with dark lava patches intermingled with the bright highlands.

Seen from above, Mare Orientale describes a roughly circular region containing mostly dark lava. Some lightening of the surface occurs mostly towards the eastern side of the sea which is the part most easily seen from Earth. Three rather challenging craters adorn the sea which may be glimpsed from Earth: 55km **Maunder** in the north, 41km **Kopff** in the east and 16km **Hohmann** in the centre. Be under no illusion, though – these are tough!

If we could see Mare Orientale face-on, the most impressive aspect would be the two large, circular rings of mountains that encircle it. Together with the mare, these form the **Orientale Basin**. Dramatic mountain ranges can be found outlining these rings, the eastern ones representing good targets to try to see from Earth. The inner ring is around 580km across and home to **Montes Rook**, a 600km-long and 100km-wide range. The outer ring has a diameter of around 1,000km and on its eastern side is defined by the impressive mountains of the 900km-long and 250km-wide **Montes Cordillera** range.

Both ranges present great observing opportunities when libration is favourable and when illuminated by a low Sun. However, even if the angle of the Sun is high, a series of dark lava lakes between the ranges and on the inner side of Montes Rook also present good opportunities for study, showing excellent contrast between their surfaces and that of the surrounding mountains.

The largest outer lake is **Lacus Autumni** which is around 140km long and 60km wide. Inside the Montes Rook ring is **Lacus Veris**, which is around 500km long and 70km wide in the east. The Orientale Basin takes a bit of decoding, even under favourable libration, but any efforts are greatly rewarded when you realise what it is you are actually seeing.

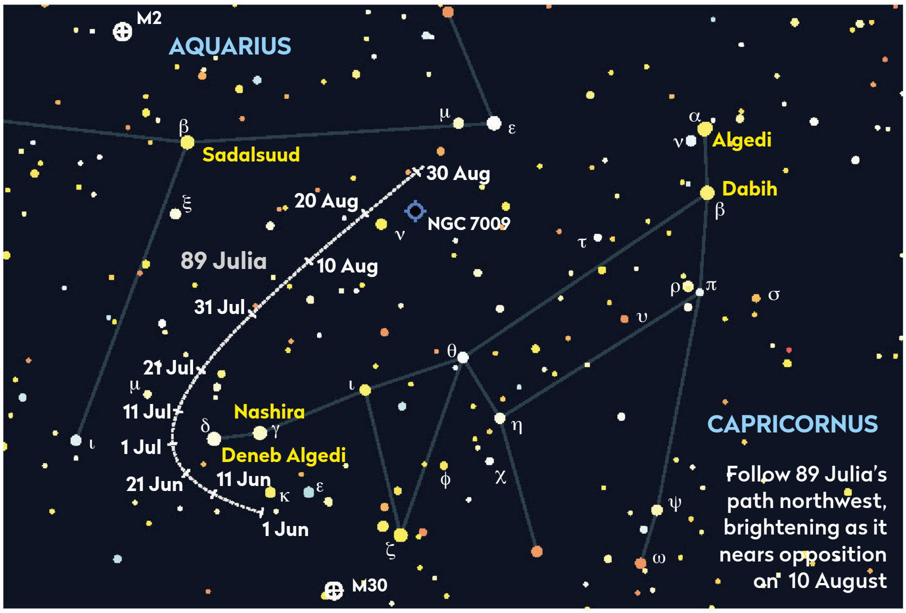


You need a favourable libration and phase to see Mare Orientale on the Moon's west edge

PETE LAWRENCE X 3

COMETS AND ASTEROIDS

Start tracking main-belt asteroid 89 Julia now



Follow 89 Julia's path northwest, brightening as it nears opposition on 10 August

Minor planet 89 Julia next reaches opposition on 10 August 2025, when it can be found among the stars of southwest Aquarius, north of the triangular-shaped pattern of Capricornus. On 1 June at 01:00 BST (00:00 UT), 89 Julia shines at mag. +10.7, 49 arcminutes southeast of mag. +4.7 Kappa (κ) Capricorni. It then traces an arc around the eastern tip of Capricornus's main triangle, lying 1.6° east of mag. +2.9 Deneb Algedi (Delta (δ) Capricorni) at 01:00 BST (00:00 UT) on 1 July. The arc then continues northwest throughout the rest of July, the minor planet increasing in brightness from mag. +10.2 on 1 July to +8.7 on 10 August when at opposition.

The bright, non-dark June sky will present issues with keeping track of Julia, but you'll have a good chance if you use photography. Of course, as we head towards the end of July, the skies will start to darken and, coupled with the minor planets brightening, this will present a great target to try to keep up with using a small telescope or a camera setup.

89 Julia is a large main-belt asteroid with an estimated diameter of around 150km. It orbits at a mean distance of 2.6 AU, swinging as close as 2.1 AU and out as far as 3.0 AU from the Sun over the course of its 4.1-year orbit. It's classed as an S-type or siliceous asteroid. Discovered in 1866 by the French astronomer Édouard Stephan, the name Julia is understood to refer to Saint Julia of Corsica.

STAR OF THE MONTH

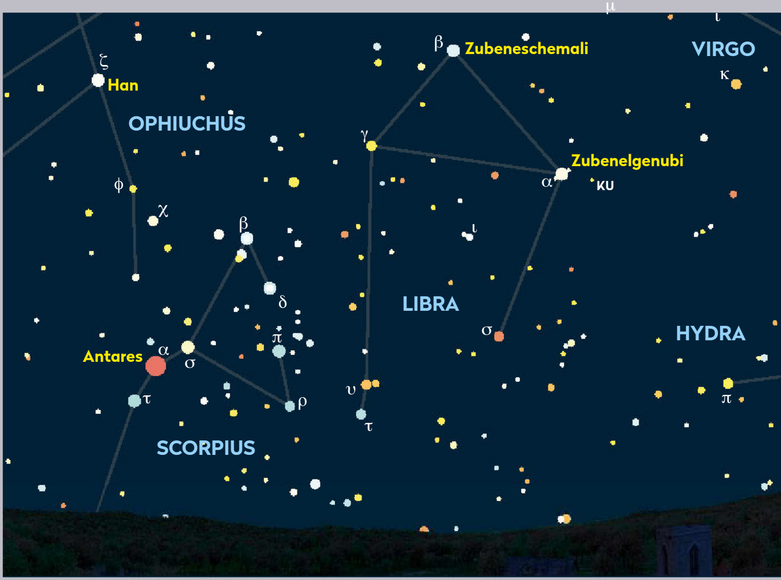
Zubenelgenubi, a claw without a scorpion

While the June sky never gets properly dark, it does mean brighter stars get a chance to stand out unencumbered by their fainter neighbours. This is certainly the case with the two primary stars of Libra, Zubenelgenubi (Alpha (α) Librae) and Zubeneschemali (Beta (β) Librae), which pass low across the southern horizon at this time of year.

'Zuben' comes from the Arabic for claw, 'al-zubānā', and the two stars translate as 'northern claw' (Zubeneschamali) and 'southern claw' (Zubenelgenubi). Libra represents the scales, an object not in need of too many claws! But both stars, located northwest of Antares (Alpha (α) Scorpii), once belonged to Scorpius. Zubenelgenubi is a double star, Alpha^1 (α^1) and Alpha^2 (α^2) Librae; the name Zubenelgenubi is attached to the brighter component, mag. +2.7 Alpha^2.

Alpha^1 is an F3-type mag. +6.0 star. It is 1.5 times more massive than our Sun, 1.4 times larger and a spectroscopic binary, the two components separated in space by around 10 AU. Alpha^1 and Alpha^2 orbit each other every 70.3 days and are 5,400 AU apart. Alpha^2 is an A3-type star twice as massive as our Sun and 2.2 times larger. Like Alpha^1, it's a spectroscopic binary.

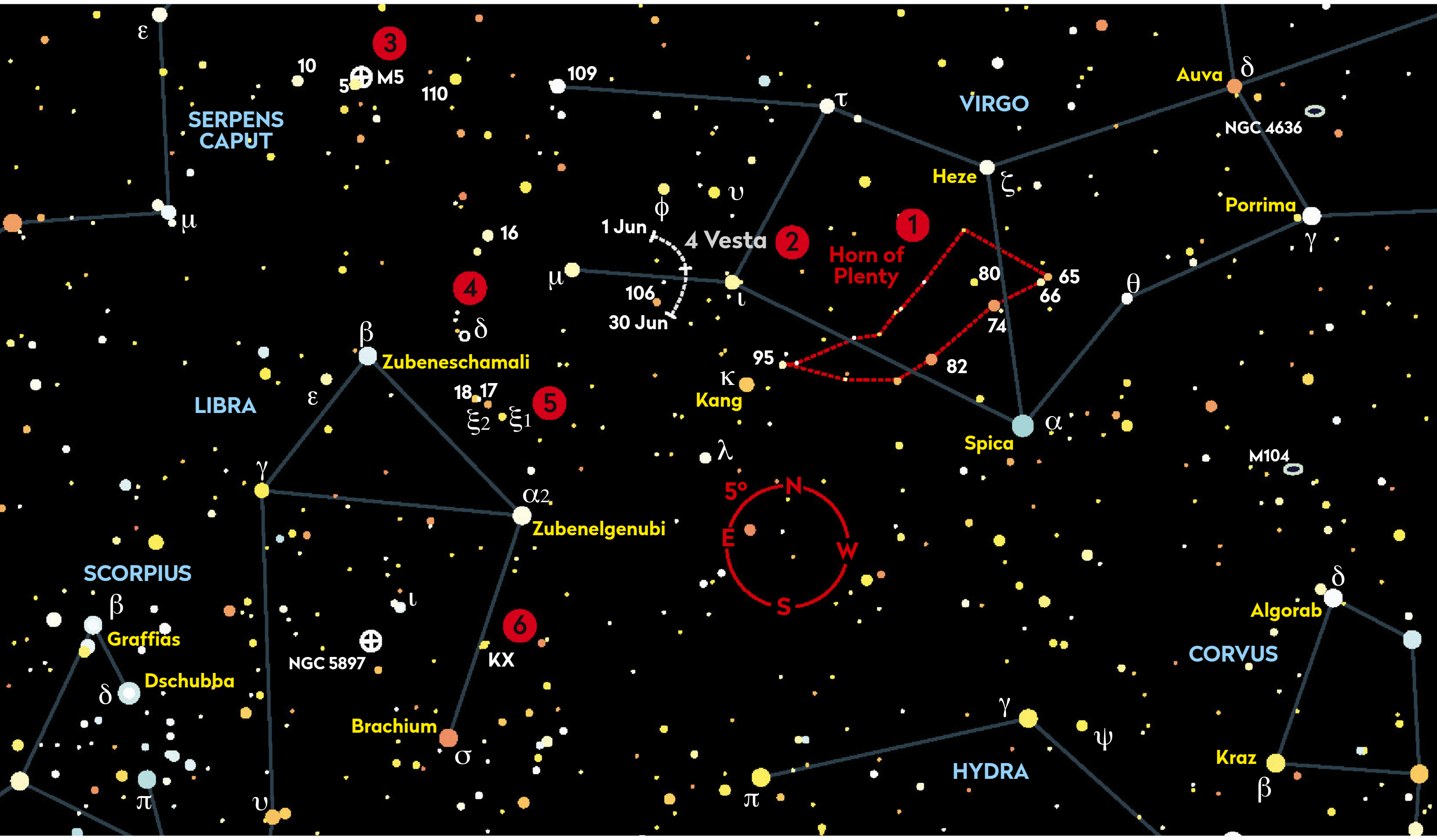
▼ The double star Zubenelgenubi (Alpha (α) Librae) was once the southern claw of Scorpius



Another star, mag. +7.2 KU Librae, 2.6° from the pair and nearly four lightyears away, shares a common motion with them. If connected to the two spectroscopic binaries, they'd form a quintuplet system 75 lightyears from Earth.

BINOCULAR TOUR With Steve Tonkin

Start from a horn of plenty, stop by the Milky Way's oldest stars and end on a multiple



1. The Horn of Plenty

10x50 Look 2° northwest of mag. +4.2 Kang (Kappa (κ) Virginis) to see a little trio of stars, the brightest of which is mag. +5.5 95 Virginis. This marks the convergence of two irregular long arcs of stars that create a horn-shaped asterism extending about 12° to the northwest. In mythology, Virgo is often depicted as carrying an ear of wheat, marked by mag. +1.1 Spica (Alpha (α) Virginis), and a cornucopia. Is this the latter? ☐ **SEEN IT**

2. Vesta

10x50 Vesta, the fourth asteroid to be discovered (in 1807 by Heinrich Olbers), was named after the Roman goddess of the hearth by mathematician Carl Friedrich Gauss, whose calculations confirmed the orbits of early asteroid discoveries. In June, watch it travel a tight arc from mid-way between mag. +4.8 Phi (ϕ) Virginis and mag. +5.4 106 Virginis, finishing near the latter as it fades by half a magnitude from mag. +6.5. ☐ **SEEN IT**

3. M5

10x50 This globular cluster is adjacent to mag +5.0 5 Serpentis and may just be visible to your naked eye if you have a dark, transparent sky. Its stars are deficient in heavy elements and among the oldest stars you can see; they're thought to have formed soon after our Galaxy. With 10x50 binoculars, you'll see that this fifth object in Messier's catalogue of non-comets brightens towards the centre, just like a comet does. ☐ **SEEN IT**

4. Delta Librae

10x50 The variable (mag. +5.8 to mag. +4.4) Delta (δ) Librae lies just over halfway from M5 to Zubenelgenubi (Alpha (α) Librae). It is an eclipsing binary star, that is, a pair of stars in orbit around their common barycentre, with the orbital plane approximately along our line of sight. It has a period of 2.3 days so, even with the short summer nights, you should have several opportunities to notice its magnitude change. ☐ **SEEN IT**

5. Xi^1/Xi^2 and 17/18 Librae

10x50 Between Delta Virginis and Zubenelgenubi lie two easy pairs of stars. The very wide pair of orange stars are mag + 5.8 Xi^1 (ξ^1) and mag. +5.4 Xi^2 (ξ^2) Librae, separated by 0.75°. Half a degree northeast of Xi^2 is the other pair, mag. +6.6 17 and mag. + 5.8 18 Librae, nearly 10 arcminutes apart. These are 'visual binaries', line-of-sight illusions, and neither pair is physically related. ☐ **SEEN IT**

6. KX Librae

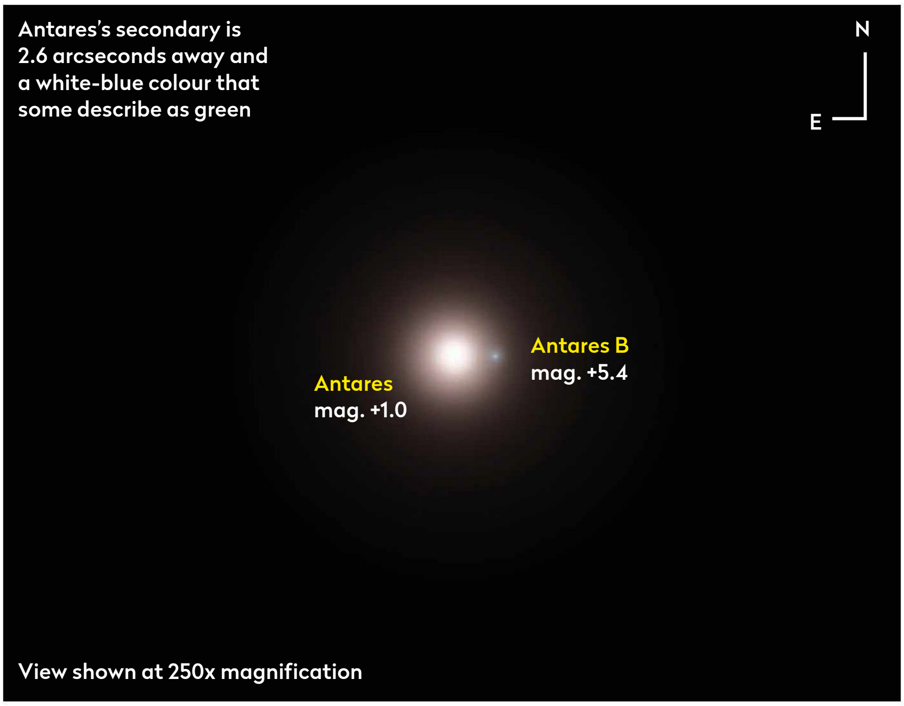
15x70 From Zubenelgenubi, navigate 5.5° towards mag. +3.3 Brachium (Sigma (σ) Librae) to find a mag +5.8 deep-yellow star. Look closer and you'll see it appears to be a double, with an eighth-magnitude companion 26 arcseconds to the north-west. This fainter companion is actually a pair of red dwarf stars. Recently, a brown dwarf companion was confirmed, making this a quadruple system! ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

You'll know red supergiant Antares. But can you spot Antares B, its blue companion?



Antares's secondary is 2.6 arcseconds away and a white-blue colour that some describe as green

View shown at 250x magnification

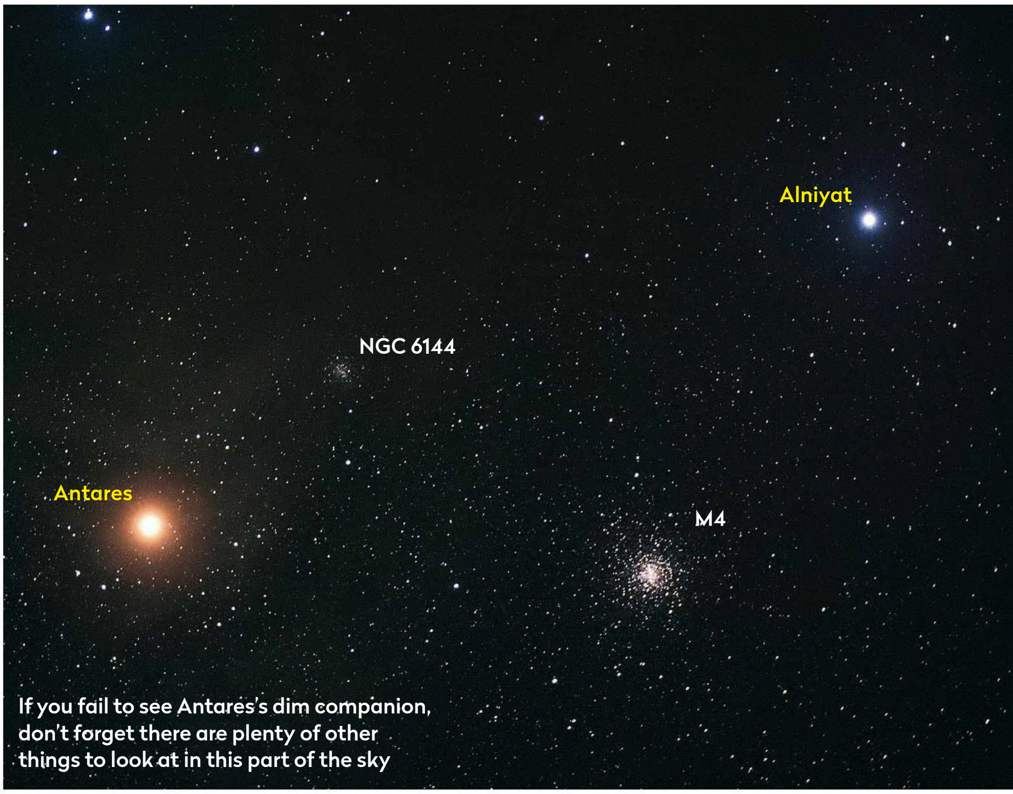
During June evenings, the beautiful red supergiant Antares (Alpha (α) Scorpii) can be seen passing above the southern horizon. This 'rival of Mars' represents the heart of Scorpius, the scorpion, a constellation that's reduced in intensity for UK observers because it doesn't rise high enough above the southern horizon. Fortunately, this is not the case for Antares, which can reach the giddying heights of 10° altitude when due south. Okay, that's not great, but Antares is bright enough to punch through any gentle summer haze and stands out really well. This month's challenge lurks within the glare of Antares.

Antares shines at mag. +1.0 and has a beautiful orange hue – hence the comparison to Mars, the two objects not appearing totally dissimilar. Like many stars, Antares is not alone in space and has a companion. The companion shines at mag. +5.4 but appears very close to Antares, with a separation of just 2.6 arcseconds. This, combined with low-altitude atmospheric unsteadiness, can make this otherwise quite bright companion a little tricky to see.

Antares B, as it's known, is a B2.5-class star, which means it shines with a blueish light. Antares is a M1.5Iab–Ib type, which means it shines as an orange star, as we've already mentioned, and is easy to see with just your eyes. The proximity of the bright-orange primary Antares A so near the blue secondary Antares B gives rise to a classic colour-contrast situation, making the secondary appear greenish.

Separating the pair can be a real challenge. Any atmospheric disturbance – and there tends to be a lot at 10° altitude – will result in the light from Antares A bleeding across the region where Antares B is located. A night of steady air is best and it doesn't necessarily need to be fully dark; a slight brightening of the sky will serve to reduce the primary star's contrast. Antares B has been reported in scopes as small as 80mm, but it has also been hidden from scopes over 250mm aperture under unsteady conditions.

The best strategy for spotting Antares B is to keep trying. Use a low-power eyepiece and assess the stability of the atmosphere. If it seems steady, then up the power. The best value will vary according to the type of scope and the conditions, but the pair can be seen well at x100. Go higher if conditions allow though. Don't expect this challenge to be satisfied quickly; it can take years to see the companion if the weather doesn't cooperate. The good news is that checking the conditions can be done quickly, with Antares being easy to find during the summer months.



If you fail to see Antares's dim companion, don't forget there are plenty of other things to look at in this part of the sky

DEEP-SKY TOUR

Uncover clusters, globulars and nebulae around the Serpent's Tail, Serpens Cauda

1 IC 4756

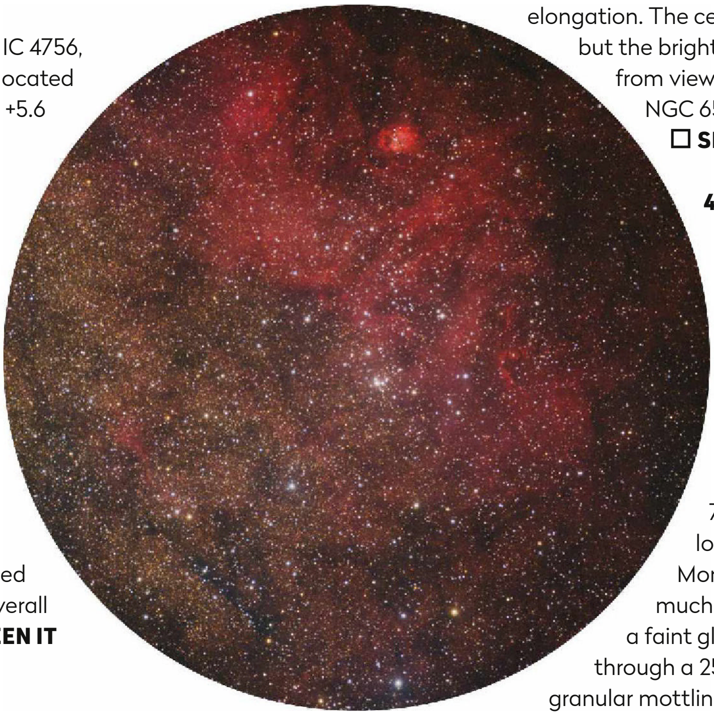
We start with open cluster IC 4756, right at the top of the tail, located 4.2° west and 0.9° north of mag. +5.6 Alya (Theta^1 (θ^1) Serpentis). It's a large, bright object perfectly suited for a small telescope using a low power. It's known as Graff's Cluster after the Polish-German astronomer Kasimir Romuald Graff, and also as the Secret Garden Cluster. Another name for it is the Tweedledee Cluster, it being the larger of a pair with our next target, NGC 6633. The background sky here is rich in faint Milky Way stars, IC 4756 appearing as an irregularly shaped bright patch among them. Its overall diameter is just short of 1°. ☐ **SEEN IT**

2 NGC 6633

If IC 4756 is the Tweedledee Cluster, it stands to reason that its 'twin', NGC 6633, is the Tweedledum Cluster. NGC 6633 is located in Ophiuchus, 3° west and 0.8° north of IC 4756. It's a smaller object and more elongated, with an apparent size of 45 x 20 arcminutes. Its outer stars form a banana-shaped outline leading to it becoming known as the Captain Hook Cluster and, perhaps more appropriately, the Wasp Cluster. With a good imagination, you can imagine the thorax and abdomen of a wasp. A small scope reveals around 40 stars, which double in a 250mm instrument. NGC 6633 lies at a distance of 1,000 lightyears; its 'twin' IC 4756 is slightly further at 1,300 lightyears. ☐ **SEEN IT**

3 NGC 6572

We remain in Ophiuchus for our next target, NGC 6572, a tiny but bright planetary nebula known as the Blue Racquetball Nebula, 3.9° west of NGC 6633. Its apparent size is only 16 x 13 arcseconds, not dissimilar to the maximum apparent size of Mars during opposition at the start of 2025. At mag. +8.1, it's an easy target through a 150mm scope, its tiny size being the issue, making NGC 6572 appear like a star at low magnification. You'll need a bit of aperture to reveal the nebula's greenish hue and distinct north–south elongation. The central star shines at mag. +13.6, but the bright surface of the nebula hides it from view through large instruments. NGC 6572 is 6,030 lightyears away. ☐ **SEEN IT**



▲ **Young cluster NGC 6604, the last stop on our tour, is an easy one for small scopes**

KONSTANTIN VON_POSCHINGER/CCDGUIDE.COM, CHART BY PETE LAWRENCE

4 NGC 6535

We slip back into Serpens Cauda for our next target, globular cluster NGC 6535. Locate it by first identifying 70 Ophiuchi, part of the V-shaped asterism known as Poniatowski's Bull, a 3° pattern 4.3° south-southwest of NGC 6572. From mag. +4.0 70 Ophiuchi, head south 2.6° to locate the mag. +10.5 globular. More aperture is needed to see much here, NGC 6535 appearing like a faint glow in a star-rich area of sky through a 250mm scope. There's some granular mottling visible, but the stand-out feature is the arc of 13th-magnitude stars adorning the western edge. A 300mm instrument reveals a 1.5-arcminute object on the edge of being resolved. NGC 6535 is 22,000 lightyears distant. ☐ **SEEN IT**

5 NGC 6539

Heading 7.3° south brings you to our penultimate tour stop, NGC 6539, another globular cluster. This one shines at mag. +9.8 and can be seen through smaller scopes as a definite concentrated patch. Lying at a distance of 26,700 lightyears, this cluster doesn't appear much more than a glow even through larger apertures. A 250mm scope reveals an object around 4 arcminutes across, but the cluster stars are unresolved. A 300mm scope shows a little more detail and though it still won't resolve the member stars, it will show the core region to be mottled in a rather clumpy fashion. ☐ **SEEN IT**

6 NGC 6604

Our final target is the bright, compact open cluster NGC 6604, 5.7° south-southeast of NGC 6539 and just 1.5° north of the famous Eagle Nebula, M16. NGC 6604 is 4,580 lightyears distant, a young 6.5-million-year-old cluster that shines at mag. +6.5, making it an easy target for smaller scopes. Its brightest star is a high-mass triple-star system that contains the over-contact (both stars in contact) eclipsing binary MY Serpentis (HD 167971). Shining at mag. +7.7, this represents one of the visually most luminous O-type stars in the Galaxy. A 300mm scope will reveal a lovely arc-shaped asterism of five stars forming the heart of the cluster. ☐ **SEEN IT**

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can take you to this month's targets at the touch of a button. Find the Deep-Sky Tour file in our free Bonus Content online.

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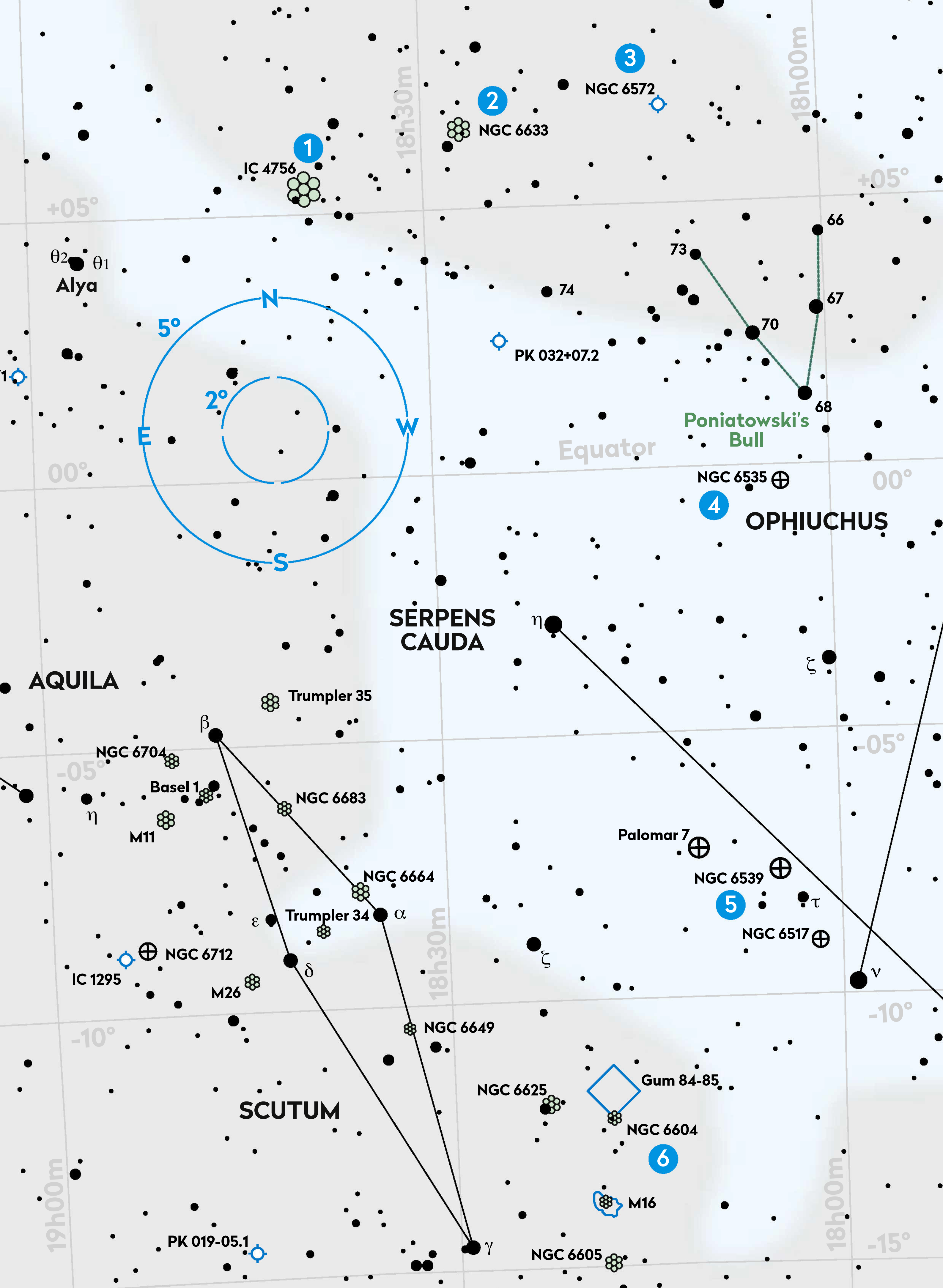
3
NGC 6572
2
NGC 6633
1
IC 4756
18h30m
18h00m
+05°
+05°
66
73
67
74
70
68
θ2
θ1
Alya
N
5°
2°
E
W
S
PK 032+07.2
Poniatowski's Bull
Equator
00°
00°
NGC 6535
4
OPHIUCHUS
SERPENS CAUDA
η
ζ
AQUILA
Trumpler 35
β
NGC 6704
-05°
-05°
Basel 1
η
M11
NGC 6683
Palomar 7
NGC 6539
NGC 6664
5
τ
ε
Trumpler 34
α
NGC 6517
NGC 6712
IC 1295
δ
M26
ζ
ν
18h30m
-10°
-10°
NGC 6649
Gum 84-85
NGC 6625
SCUTUM
NGC 6604
6
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γ
NGC 6605
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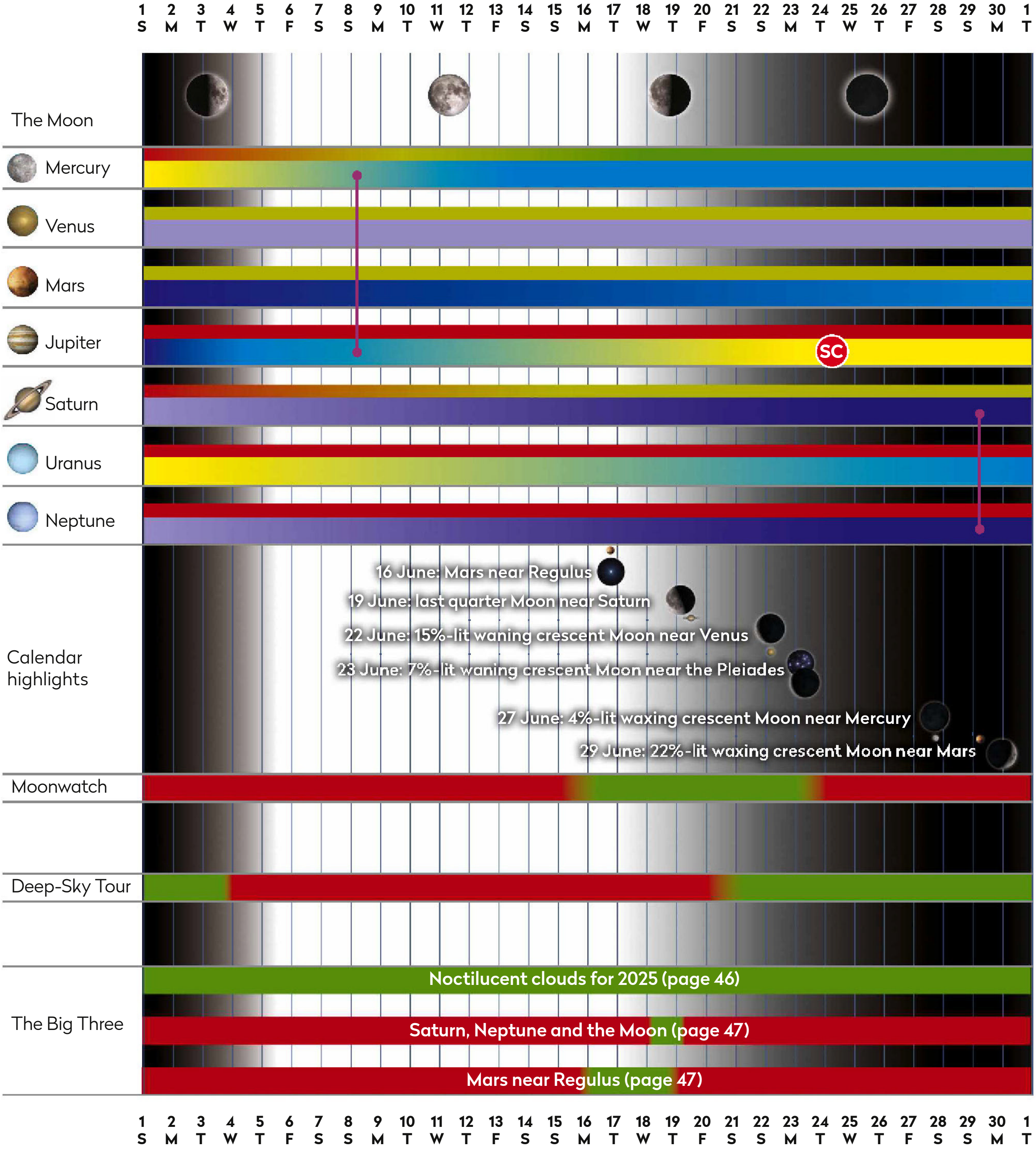
AT A GLANCE How the Sky Guide events will appear in June



16 June: Mars near Regulus

19 June: last quarter Moon near Saturn

22 June: 15%-lit waning crescent Moon near Venus

23 June: 7%-lit waning crescent Moon near the Pleiades

27 June: 4%-lit waxing crescent Moon near Mercury

29 June: 22%-lit waxing crescent Moon near Mars

KEY

Observability 🟩 Optimal 🟥 Poor

Best viewed Morning twilight, Daytime, Evening twilight, Night

Sky brightness during lunar phases Dark (first quarter), Light (full Moon), Dark (last quarter), Total darkness (new Moon)

IC Inferior conjunction (Mercury & Venus only)

SC Superior conjunction

OP Planet at opposition

△ Meteor radiant peak

Planets in conjunction

Full Moon

First quarter

Last quarter

New Moon

CHART BY PETE LAWRENCE

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Hunting killer asteroids

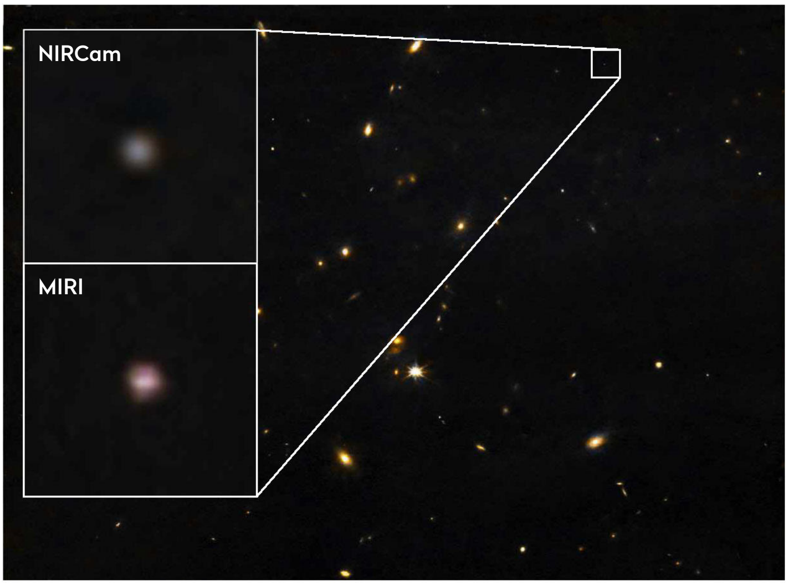
Earlier this year, an asteroid appeared to be on a collision course with Earth. **Jenny Winder** looks at how astronomers came to declare it a near-miss and how Earth can be defended from dangerous rocks from space

ILLUSTRATION: TOLGA TEZCAN/DOTTEDHIPPO/GETTY

On 27 December 2024, the Asteroid Terrestrial-impact Last Alert System (ATLAS) telescope in Rio Hurtado in Chile discovered asteroid 2024 YR4 speeding past Earth. The detection could have been too late; only two days before, on Christmas Day, the asteroid had been just 828,800km (515,000 miles) from Earth. As astronomers plotted out the path of the asteroid, they realised Earth might not always be so lucky – there was a chance the asteroid could impact our planet in December 2032.

Telescopes across the globe have been gathering data on YR4 ever since. Chief among these was the Nordic Optical Telescope in La Palma which analysed the asteroid's size, shape and rotation, as well as its motion and exact position. This helped to refine its current orbit and predict its future trajectory. By February 2025, calculations seemed to confirm that its highly elliptical orbit would ▶

It's highly likely that a big asteroid will one day head directly for Earth. So what's the plan?



▶ In the clear: YR4 pictured journeying back out into the Solar System after triggering panic on Earth earlier this year

▶ have a 3 per cent chance of impact with Earth. In April, the James Webb Space Telescope observed YR4 and calculated that it is between 53 and 67 metres across (174–220ft). It has an estimated mass of 220 million kg (485 million lb) and rotates once every 19.5 minutes – relatively fast for an asteroid. Its magnitude changes by 0.42 as it rotates, indicating it probably has an elongated shape. It orbits Earth once every 3.99 years, meaning it will revisit Earth once more in 2028 before the 2032 pass that caused alarm.

While an asteroid this size isn't an extinction-level threat, it could cause severe damage at a local level. An asteroid of this size is expected to impact Earth every few thousand years and can cause devastation either by impacting Earth's surface or by exploding in our atmosphere.

Warning from Chelyabinsk

For comparison, the 2013 Chelyabinsk meteor that exploded in a meteor airburst over Russia was about 18 metres (60ft) across and weighed just 9,100 tonnes (9.1 million kg or 20 million lb). However, the shockwave was estimated to have 33 times the energy produced by the atomic bomb at Hiroshima. It damaged 7,200 buildings in six cities across the region, with the resulting debris injuring 1,491 people.

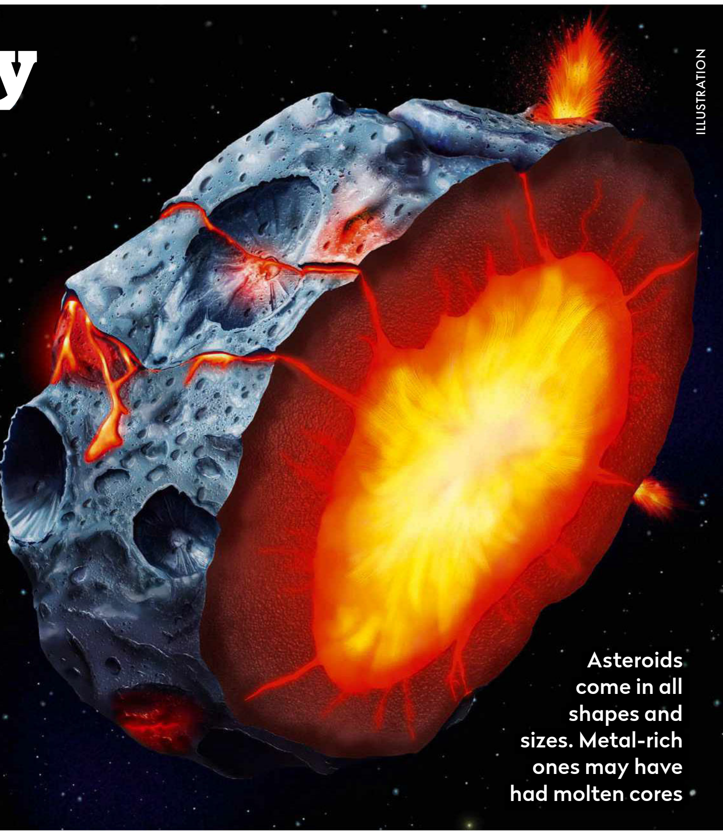
Shockwave damage after an asteroid exploded above Chelyabinsk in February 2013

Composition is key

Different kinds of asteroids will need to be dealt with in different ways

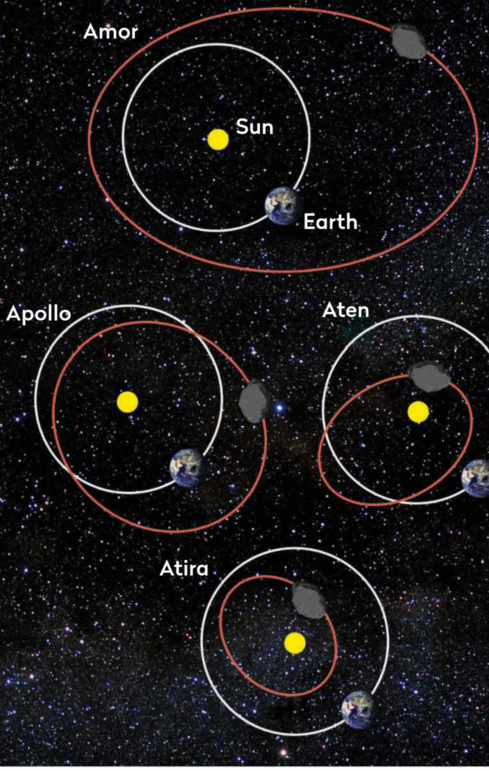
Asteroids can have a wide variety of compositions. They can be made of rock, metals and even water. There are very dark chondrite or C-type asteroids which are the primitive leftovers from planet formation that have remained largely unchanged for billions of years. There are also metallic M-type asteroids and grey stony S-type asteroids, which is what YR4 is thought to be. Though there have been missions to analyse asteroids close up, their composition is usually estimated remotely by measuring their albedo (how much light is reflected from the surface) and spectra, and by calculating their density. Most stony asteroids are made of loose rubble formed by collisions and bound by gravity, though only the largest have enough mass to pull them into a spherical shape. Metallic asteroids are more solid, suggesting they were molten at some point, possibly the remnants of the cores or mantles of protoplanets.

If we were to find a potential killer asteroid, understanding its composition would be key to dealing with the threat. For instance, if an impact mission were sent to deflect it, a metal asteroid would probably remain whole, while a rubble-pile asteroid could break up into multiple smaller, though still dangerous, lumps of rock.

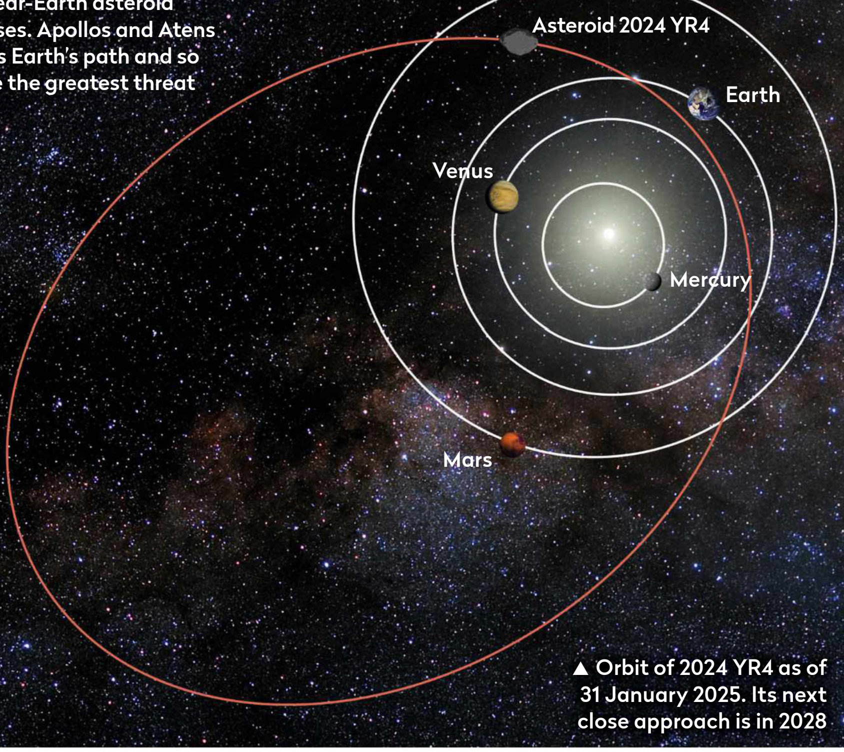


ILLUSTRATION

Asteroids come in all shapes and sizes. Metal-rich ones may have had molten cores



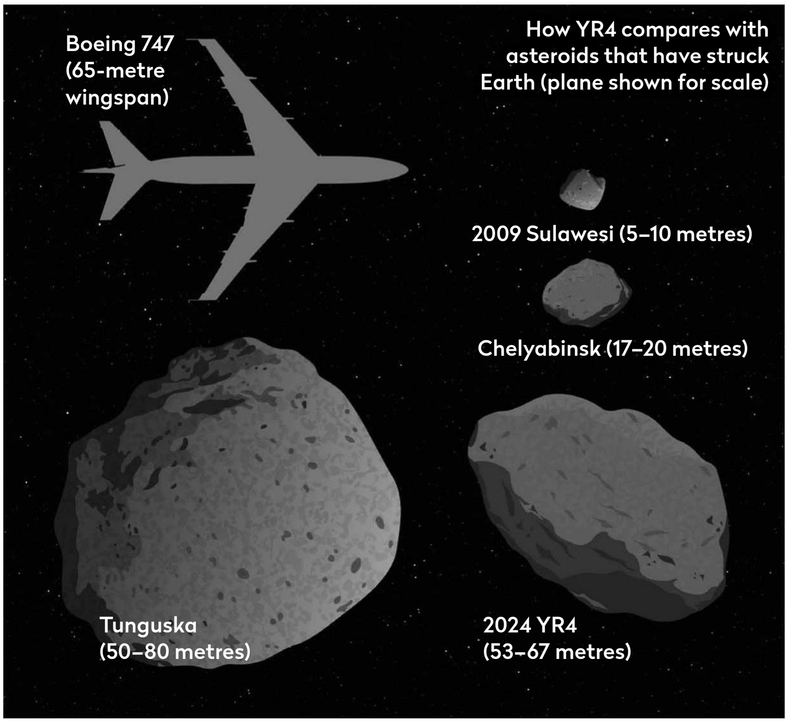
◀ Near-Earth asteroid classes. Apollos and Atens cross Earth's path and so pose the greatest threat



▲ Orbit of 2024 YR4 as of 31 January 2025. Its next close approach is in 2028

Most asteroids reside in the main belt between Mars and Jupiter, which contains between one and two million asteroids larger than 1km (0.6 miles) in diameter, and millions of smaller ones. Near-Earth asteroids (NEAs) are defined as any object that comes within 1.3 AU of the Sun, where 1 AU is the Earth–Sun distance. They are divided into groups based on their orbits: Atira asteroids orbit within the orbit of Earth; Atens have orbits of less than 1 AU that cross Earth's orbit; Armors orbit beyond Earth. YR4 is an Apollo asteroid, meaning it has an orbit larger than 1 AU that crosses Earth's path.

Any asteroid over 50 metres (164ft) and with a more than 1 per cent probability of impacting Earth within the next 50 years activates the International Asteroid Warning Network (IAWN) and the Space Mission Planning Advisory Group (SMPAG) to coordinate a response. Researchers use the Torino scale to measure the potential threat of asteroids, a scale from 0 (virtually no risk of collision) to 10 (catastrophic collision with Earth is certain). The larger an asteroid is, and the higher its impact probability, the higher up the scale it will be.


Boeing 747 (65-metre wingspan)
2009 Sulawesi (5–10 metres)
Chelyabinsk (17–20 metres)
Tunguska (50–80 metres)
2024 YR4 (53–67 metres)

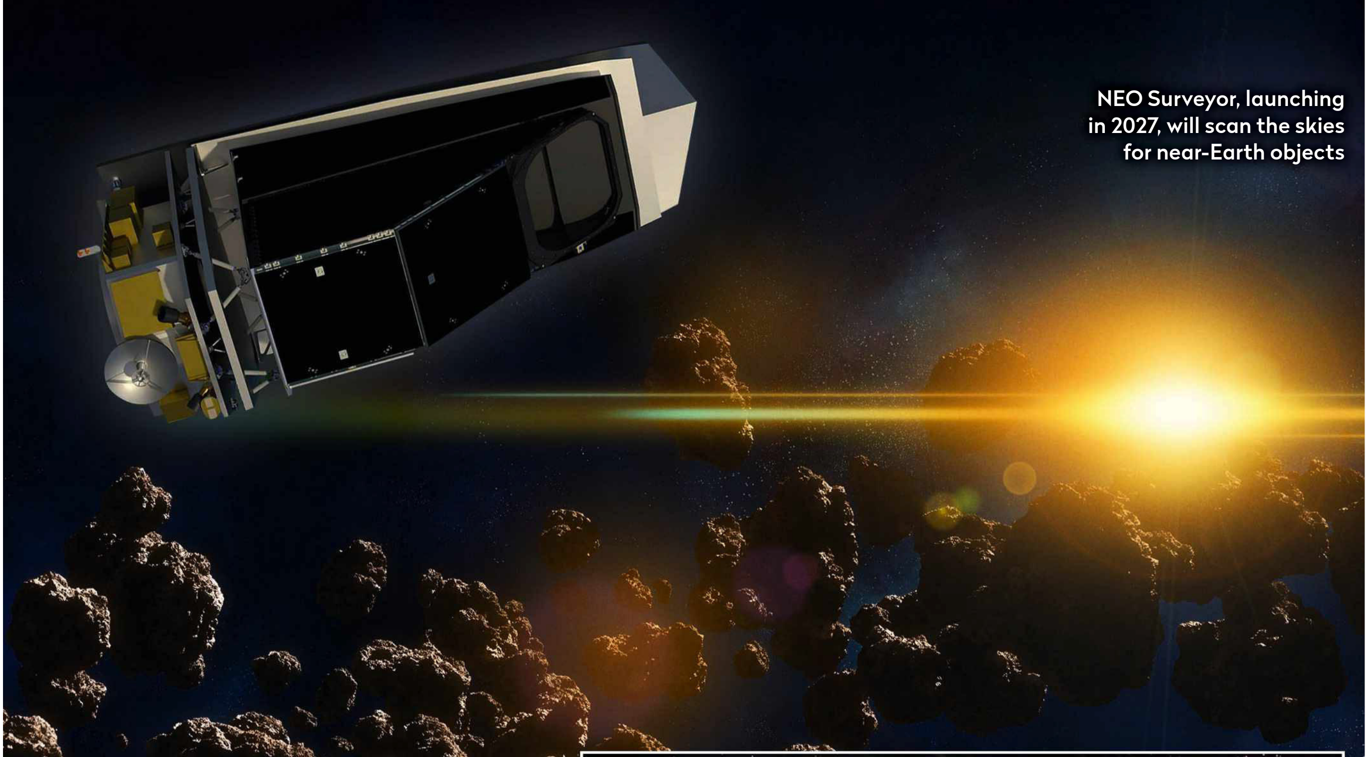
How YR4 compares with asteroids that have struck Earth (plane shown for scale)

A Torino rating of 1 is assigned several times a year to asteroids but, over a few weeks, as observations eliminate possible collision trajectories, they are routinely bumped back down to 0 again. In late 2004, the 450-metre-wide (1,476ft) asteroid Apophis 99942 was estimated to have a 2.7 per cent impact chance – the highest Torino rating ever recorded, reaching 4 on the scale. By 2006, more accurate measurements of its orbit reduced the chance of impact to zero.

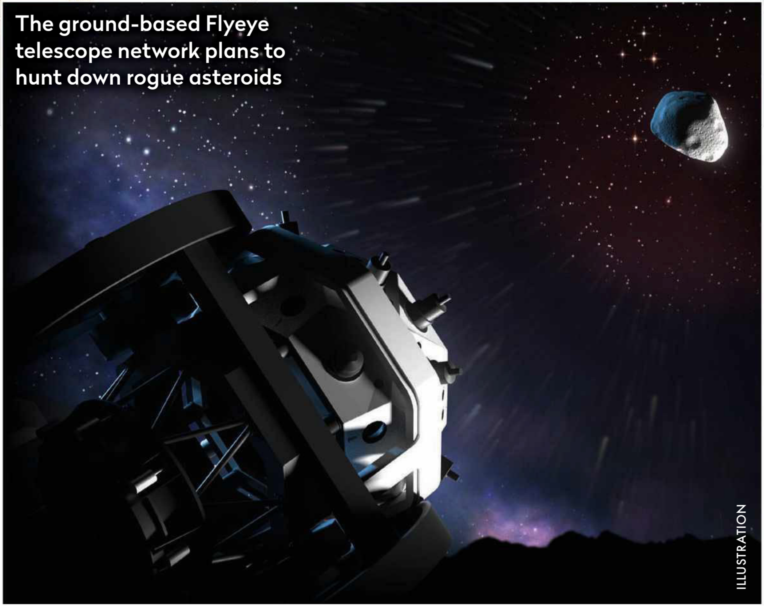
Tracking the threat from YR4

YR4 received the second-highest Torino rating ever given, rising to 3 in late January 2025, meaning it had more than a 1 per cent chance of collision likely to cause localised destruction. Fortunately for us, however, as more observations refined the asteroid's trajectory, the range of possible orbits that would collide with Earth were ruled out. At the time of writing, it's estimated that YR4 has a 0.00082 per cent chance of impact with Earth. It's now thought its closest approach to Earth will be 260,000km (160,000 miles) away at 08:46 UT (+/– 4 hours) on 22 December 2032. The Moon, however, might not be so lucky. The asteroid is estimated to pass just 3,100km (1,926 miles) away at 15:18 UT on the same day, with a 3.8 per cent chance of impacting it.

It was only in the early 1970s that the first dedicated survey, the Palomar Planet-Crossing Survey (PCAS), was established to identify and track potential asteroid threats. Asteroids are detected by comparing images of the same patch of sky and finding anything that shifts position against the background of apparently fixed stars and galaxies. Early surveys like PCAS used photographic plates and a blink comparator, a technique that allows ▶



NEO Surveyor, launching in 2027, will scan the skies for near-Earth objects



The ground-based Flyeye telescope network plans to hunt down rogue asteroids

▶ rapid switching between images. Since the 1980s, digital charged-coupled devices (CCDs), computer software and motion-detection algorithms have greatly improved our ability to identify and track asteroids and comets.

Current surveys include NASA's NEOWISE, the University of Arizona's Catalina Sky Survey (CSS) and the University of Hawaii's Panoramic Survey Telescope and Rapid Response System (Pan-STARRS). We have now identified over a million asteroids, with 38,000 near-Earth objects (NEOs), of which 1,779 are on the risk list at time of writing, meaning their probability of impact with Earth is greater than zero.

In 2027, NASA is planning to launch the infrared NEO Surveyor telescope. This will survey the Solar System from the L1 (inner) Lagrange point and is expected to discover between 200,000 and 300,000 new NEOs and calculate their orbits. Meanwhile, ESA is developing a series of automated 'Flyeye' telescopes, designed to mimic the compound eye that gives some insects a wide field of view. These telescopes will autonomously scan the entire sky every night and send alerts of new asteroid discoveries to astronomers each morning.

Ways to dodge disaster

When YR4 becomes visible again in 2028, we will learn more about its composition and refine its trajectory further. But what then? If an asteroid like YR4 was found to be on a collision course with Earth, what, if anything, could we do about it?

A lot would depend on the size and composition of the asteroid and how much time we have to take action, which is why an early warning system is crucial to our response.

There are three main options available. We could try to destroy it, hopefully breaking it into small enough pieces that they would burn up in our atmosphere. This would be very risky as it could just make the problem worse, creating multiple threats over a wider area. Any fragment more than 35 metres (115ft) across could still be a threat.

> *"We could try to destroy it, breaking it into small pieces that burn up in our atmosphere. This would be very risky"*

Another option is to do nothing, but calculate where it will impact. As our planet's surface is largely covered by oceans, a small asteroid could be allowed to impact the sea with little effect. However, for a large asteroid, even an impact at sea could be devastating. In 1981, a large iridium deposit discovered in the southern Pacific Ocean revealed an asteroid about 4km (2.5 miles) across had impacted 2.5 million years ago. This likely caused a tsunami hundreds of metres high and may have been a partial cause of the last Ice Age. An asteroid like YR4 could

NASA/JPL-CALTECH/UNIVERSITY OF ARIZONA/MACIEJ FROLOW/GETTY, ESA/A. BAKER, ESTT/
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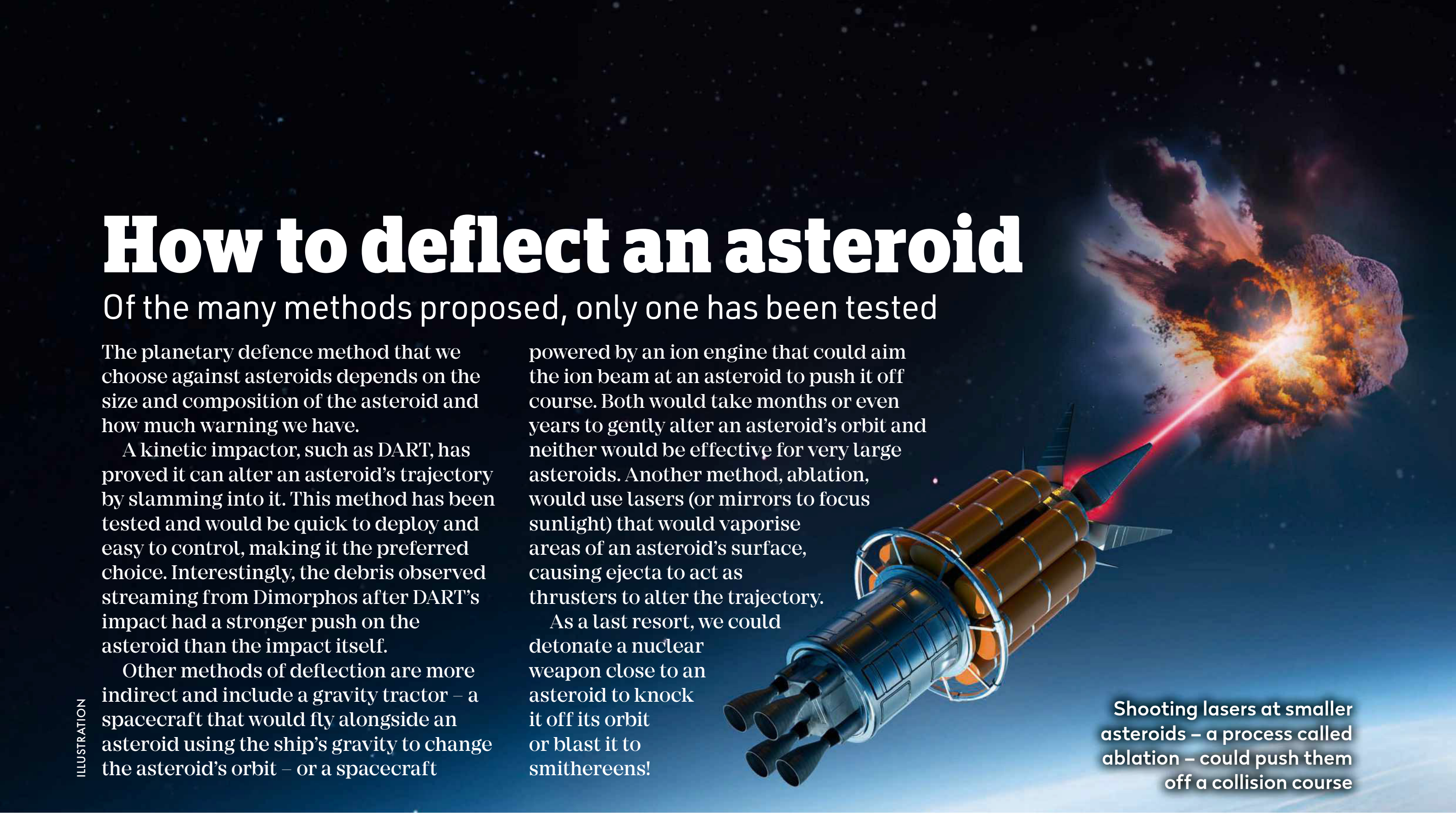


How to deflect an asteroid

Of the many methods proposed, only one has been tested

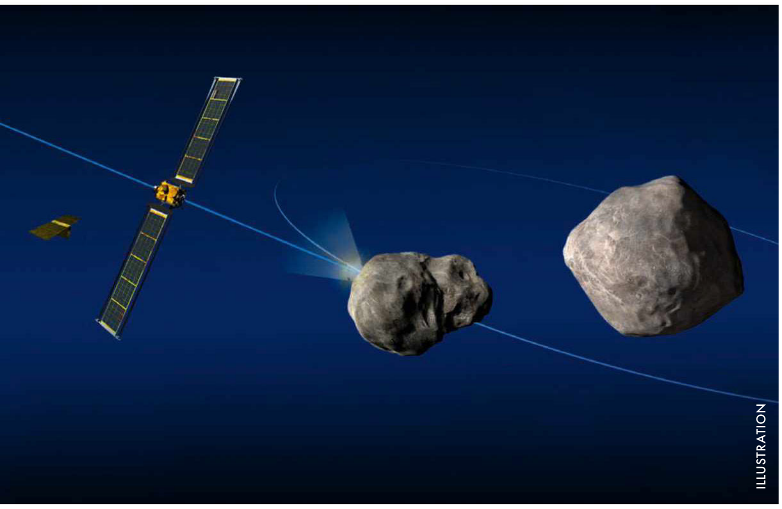
The planetary defence method that we choose against asteroids depends on the size and composition of the asteroid and how much warning we have.

A kinetic impactor, such as DART, has proved it can alter an asteroid's trajectory by slamming into it. This method has been tested and would be quick to deploy and easy to control, making it the preferred choice. Interestingly, the debris observed streaming from Dimorphos after DART's impact had a stronger push on the asteroid than the impact itself.

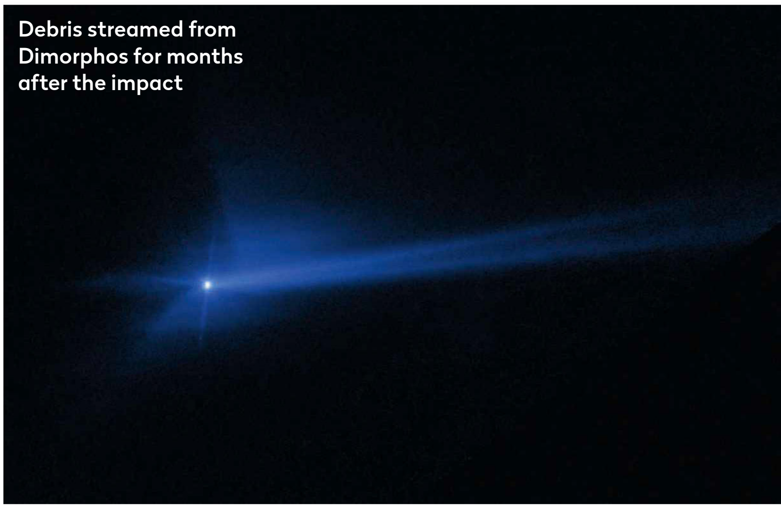
Other methods of deflection are more indirect and include a gravity tractor – a spacecraft that would fly alongside an asteroid using the ship's gravity to change the asteroid's orbit – or a spacecraft powered by an ion engine that could aim the ion beam at an asteroid to push it off course. Both would take months or even years to gently alter an asteroid's orbit and neither would be effective for very large asteroids. Another method, ablation, would use lasers (or mirrors to focus sunlight) that would vaporise areas of an asteroid's surface, causing ejecta to act as thrusters to alter the trajectory.

As a last resort, we could detonate a nuclear weapon close to an asteroid to knock it off its orbit or blast it to smithereens!

Shooting lasers at smaller asteroids – a process called ablation – could push them off a collision course



▲ The DART mission deliberately slammed into the rubble-pile asteroid Dimorphos in September 2022



Debris streamed from Dimorphos for months after the impact

cause local destruction to a small town or city centre, so if we could accurately calculate the impact zone we could evacuate that area if we had enough time.

DART to the rescue

The most practical option would be to deflect the asteroid from its orbit, either directly or indirectly, so it would miss us entirely. Fortunately, we've already taken steps to ensure this could be done.

In 2022, NASA's Double Asteroid Redirection Test (DART) successfully shortened the orbit of asteroid Dimorphos by 33 minutes and 15 seconds by hitting it head-on, proving we could move an asteroid's orbit if required. ESA's Hera mission will arrive at Dimorphos in December 2026 to assess the impact more closely. Meanwhile, China is planning its own asteroid impact and deflection mission by 2030, sending a pair of spacecraft to asteroid NEO 2015 XF261. One spacecraft will impact the asteroid and the other will observe the effect of the collision on the asteroid's orbit for a year after impact.

ESA is also planning its own Rapid Apophis Mission for Space Safety (Ramses) craft to launch in 2028. It will rendezvous with the asteroid Apophis as it passes just 32,000km (19,900 miles) from us, less than one tenth of the distance between us and the Moon, on 13 April 2029. Ramses will release two CubeSats to study how Earth's gravitational forces stretch and squeeze the asteroid.

The United Nations has designated 2029 as the International Year of Asteroid Awareness and Planetary Defense to coincide with Apophis's close approach. While there may be a killer asteroid lying in wait in the dark, Earth is doing everything it can to ensure it won't be caught by surprise.

Jenny Winder is a freelance science writer, astronomer and broadcaster

Space myths BUSTED

From frozen astronauts to rampaging black holes, **Alastair Gunn** debunks 10 things you thought you knew about space

The Universe is a big and complex beast, and doesn't always behave in the way we might expect. So it's not surprising that there are many misconceptions and misunderstandings about space.

Some common myths – like the belief that there's a 'dark side' to the Moon, for example – arise because people generally don't have a reason (or time) to question them. Others arise because they're promoted on TV, in films and online. And some simply persist because, without detailed inspection, they seem perfectly plausible. But in the Universe, not everything is as it seems…

Alastair Gunn is an astrophysicist and radio astronomer at the University of Manchester

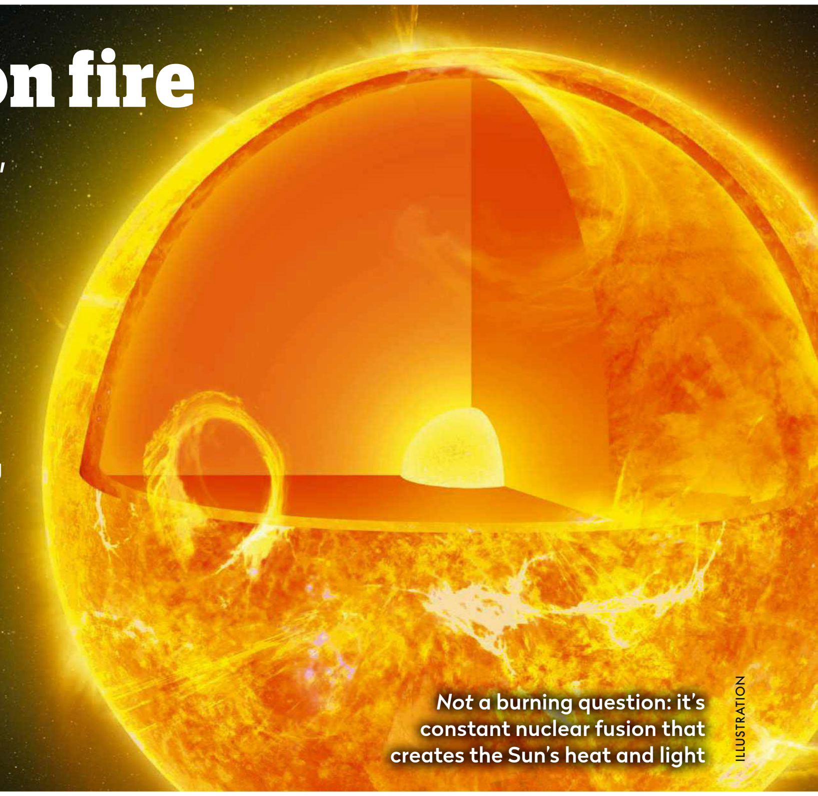
VCHAL/GETTY, TOBIAS ROETSCH/FUTURE PUBLISHING/GETTY, ESA/HUBBLE & NASA

MYTH: The Sun is on fire

Our star certainly looks like a flaming inferno, but that's not what's really going on...

The idea that the Sun is somehow burning has been around since ancient times. The Sun's heat and light were often attributed to molten metal or burning coal. But, armed with new knowledge of chemistry and thermodynamics, 19th-century scientists realised that no form of chemical energy was sufficient to fuel the Sun for more than a few thousand years. Instead of chemically combining with oxygen, like carbon does when coal is burnt, the Sun's fuel is undergoing thermonuclear reactions. Most of its energy is produced by the fusion of hydrogen into helium deep in the Sun's core, where temperature and pressure are huge.

Astronomers calculate the Sun is losing about 4.26 million tonnes of mass every second due to fusion (140 quadrillion tonnes per year). Since the Sun's mass is about 2 octillion tonnes, this is only 0.000000007 per cent of the Sun's total mass. So even at the end of its life, in about five billion years, the Sun will still have 99.966 per cent of its current mass.



Not a burning question: it's constant nuclear fusion that creates the Sun's heat and light

ILLUSTRATION

MYTH: Most of the stars we see are already dead

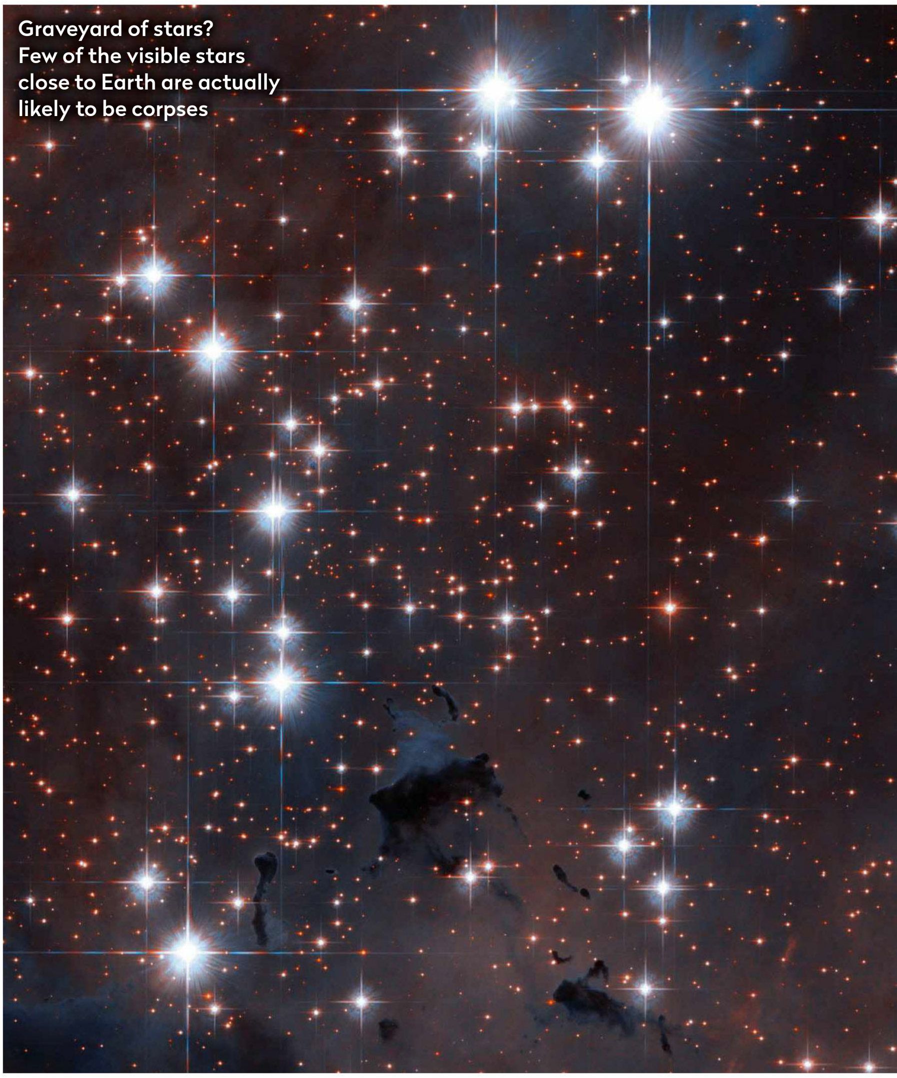
Light takes a while to reach us, so the night sky is a glimpse back in time

All the stars you can see with the naked eye lie within about 4,000 lightyears of Earth. But the most distant ones you can see are intrinsically brighter, have more mass and are therefore likely to die in supernova explosions. We can only see fainter (hence less massive) stars out to smaller distances, but these less massive stars are more likely to end their lives in less violent (but more common) deaths.

This complicates our estimates of the death rate for naked-eye stars. We can, however, choose an intermediate distance – say 1,000 lightyears – to estimate this number.

Using our knowledge of the rate of stellar deaths in the Milky Way, the death rate for *visible* stars works out at about one star every 10,000 years or so. Given all those stars are closer than 4,000 lightyears, it's unlikely, though not impossible, that any of them are already dead.

Using a powerful telescope brings many more distant stars into view, increasing the chance that some have already died. ▶



Graveyard of stars? Few of the visible stars close to Earth are actually likely to be corpses

Without a spacesuit, an astronaut would be in trouble – but they wouldn't instantly freeze to death

MYTH: Space is cold

The 'temperature' of space is harder to nail down than you think

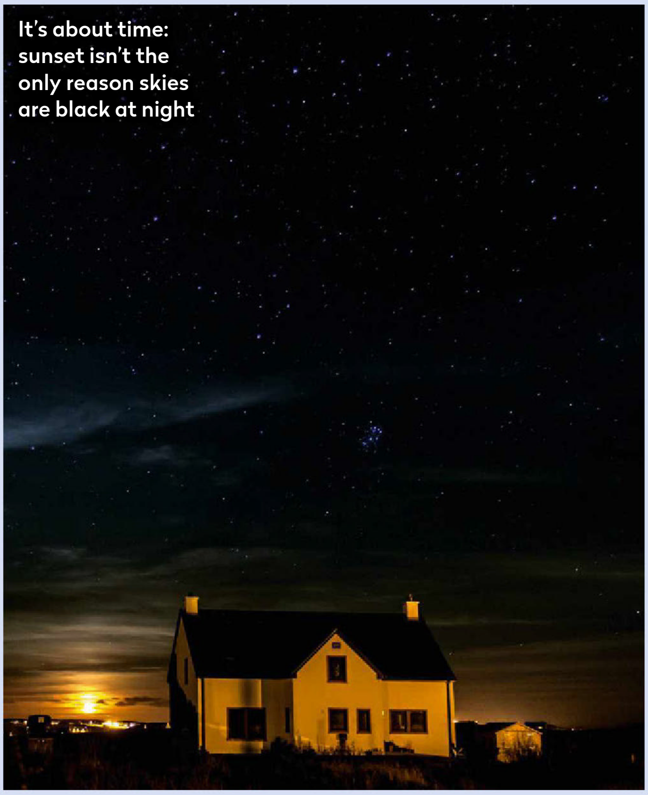
If you place an object in space, the temperature it attains depends on how much radiation it receives and how good it is at absorbing or emitting that radiation. Put it near a star and it will generally heat up, for example. Spacewalking astronauts in Earth orbit in direct sunlight can experience temperatures up to 120°C (248°F), which is far from cold. However, the object's (or astronaut's) temperature is not the temperature of 'space'. Space itself, being 'nothing', doesn't have a temperature. Astronomers *do* refer to the temperature of a region of space to indicate the kinetic energy of matter in that region. Clouds of molecular hydrogen gas are generally cold at around 10K (–263°C or –441°F), while regions between galaxy clusters can reach temperatures of 10,000,000°C (18,000,000°F). Again, by no means cold.

MYTH: The night is only dark because the Sun has gone down

Yes, it's dark when the Sun sets. But what about light from the other billions of stars?

It might seem obvious that the sky is black at night because there's no Sun to illuminate it. But in 1823, astronomer Heinrich Olbers concluded that the night sky should be as bright as the surface of the Sun! If the Universe were infinite and filled with stars, he reasoned, wherever you look you'd be looking at a star. Although light from more distant stars is weaker, there are more of them, which should result in a bright sky.

How is 'Olber's paradox' resolved? An oft-quoted explanation says the expansion of the Universe weakens the light on its journey towards us. This is true, but it's by no means enough to make the sky black. The real answer is that galaxies and the stars within them have a finite age, having first formed a few hundred million years after the Big Bang. They've only emitted a limited amount of light, so it's truer to say the night sky is black because the Universe has not existed forever.



It's about time: sunset isn't the only reason skies are black at night

ESA, PAULINE LESLEY GOODING/GETTY, ESA/HUBBLE & NASA/G. SMITH/H. EBELING/D. COE, ESA/NASA

MYTH: Dark matter is destructive

It holds galaxies together, yet it can't be seen. This is one of the Universe's greatest mysteries

Astronomers have discovered that about 85 per cent of matter in the Universe is invisible. This mysterious stuff doesn't interact with ordinary matter or radiation, but does exert a gravitational force. 'Dark matter' is the concept needed to explain many things, such as how galaxies hold themselves together and the temperature distribution of hot gas in galaxy clusters.

Yet despite its ubiquity, we have no idea what dark matter is. It may be subatomic particles like heavy neutrinos or other hypothetical particles called axions. Some of it may be undiscovered elementary particles called WIMPs (weakly interacting massive particles). But currently scientists are at a loss.

Dark matter has often been portrayed as a sinister, destructive force, as if 'dark' refers to its inherent evil. But by its very nature, this puzzling stuff doesn't interact with normal matter, from which you are made. So, it's unlikely to hurt you.

Whatever it is, 'dark' matter isn't nefarious – it just doesn't absorb, reflect or emit light

MYTH: There's no gravity in space

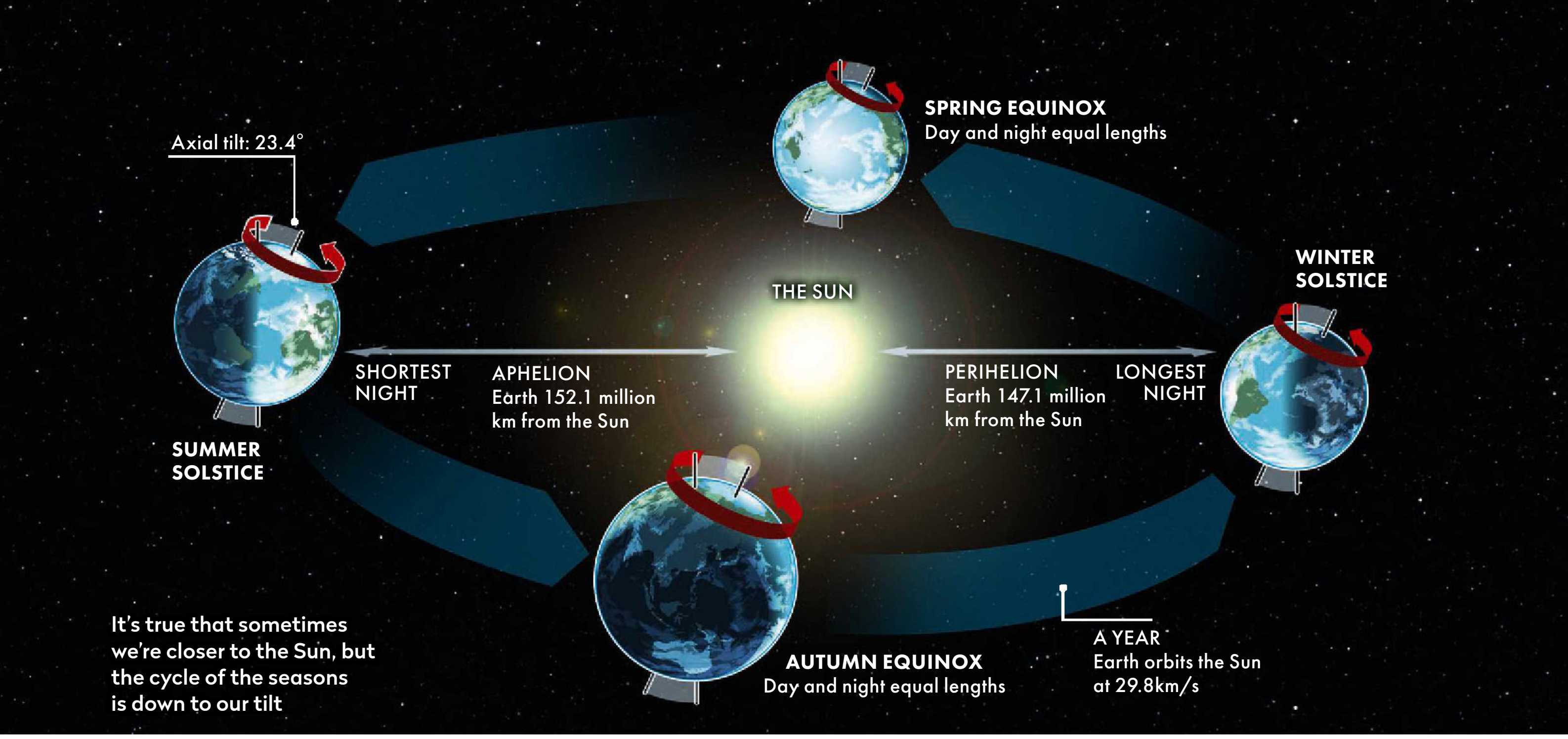
Astronauts float on the Space Station because of a lack of gravity, right?

An ISS astronaut, not in zero gravity but falling to Earth... and missing

It's common to say astronauts on the International Space Station are 'weightless' or in 'zero gravity'. But being weightless doesn't mean there's no gravity. In fact, these astronauts experience about 89 per cent of the gravitational field they'd feel here on Earth if they were about 400km (250 miles) up.

The difference is that the astronauts are in Earth orbit. They're in a continuous state of gravitational freefall, but their large orbital speed means their trajectory matches the curvature of Earth. In short, they're falling towards, but constantly missing, Earth. If they were instead standing on top of a 400km-high building, they'd feel 89 per cent as heavy as they do on the ground.

What about deep space? Space is full of gravity because the Universe is full of matter. It might be weak in places, but it's always there. It's the reason celestial bodies exist, from planets, moons and asteroids to stars and galaxies. Without gravity, we wouldn't be here. ▶


Axial tilt: 23.4°
SPRING EQUINOX
Day and night equal lengths
WINTER SOLSTICE
THE SUN
SHORTEST NIGHT
APHELION
Earth 152.1 million km from the Sun
PERIHELION
Earth 147.1 million km from the Sun
LONGEST NIGHT
SUMMER SOLSTICE
AUTUMN EQUINOX
Day and night equal lengths
A YEAR
Earth orbits the Sun at 29.8km/s

It's true that sometimes we're closer to the Sun, but the cycle of the seasons is down to our tilt

MYTH: Seasons are caused by Earth's distance from the Sun

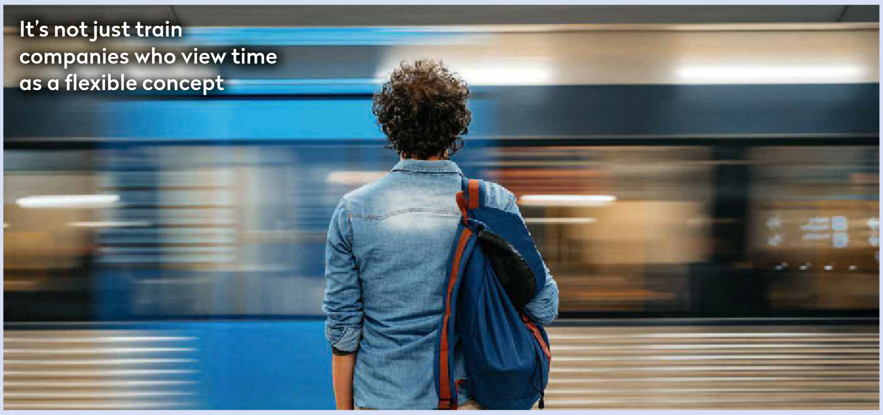
Winter's cold, summer's hot. But not because of our planet's proximity to its star

Since Earth's orbit around the Sun is slightly elliptical, its closest approach to the Sun (perihelion) is about 147 million km (91 million miles) and its furthest (aphelion) is about 152 million km (94 million miles). This 3 per cent or so difference means the Sun's light is on average 7 per cent stronger at perihelion than at aphelion. So, you might think that this creates a seasonal difference in the Sun's warmth. But perihelion occurs in January, the dead of winter for the Northern Hemisphere; yet at the same time, the Southern Hemisphere experiences its summer.

The seasons are caused by the 23.4° tilt of the Earth's spin axis from its orbital plane. As Earth moves through its orbit, first one and then the other hemisphere tilts towards the Sun. The hemisphere tipped towards the Sun experiences summer because it receives up to three times as much energy as the other (winter) hemisphere, as well as having more hours of sunlight.

MYTH: Time is the same everywhere

A ticking clock isn't the reliable constant you might think. Turns out it's all relative


It's not just train companies who view time as a flexible concept

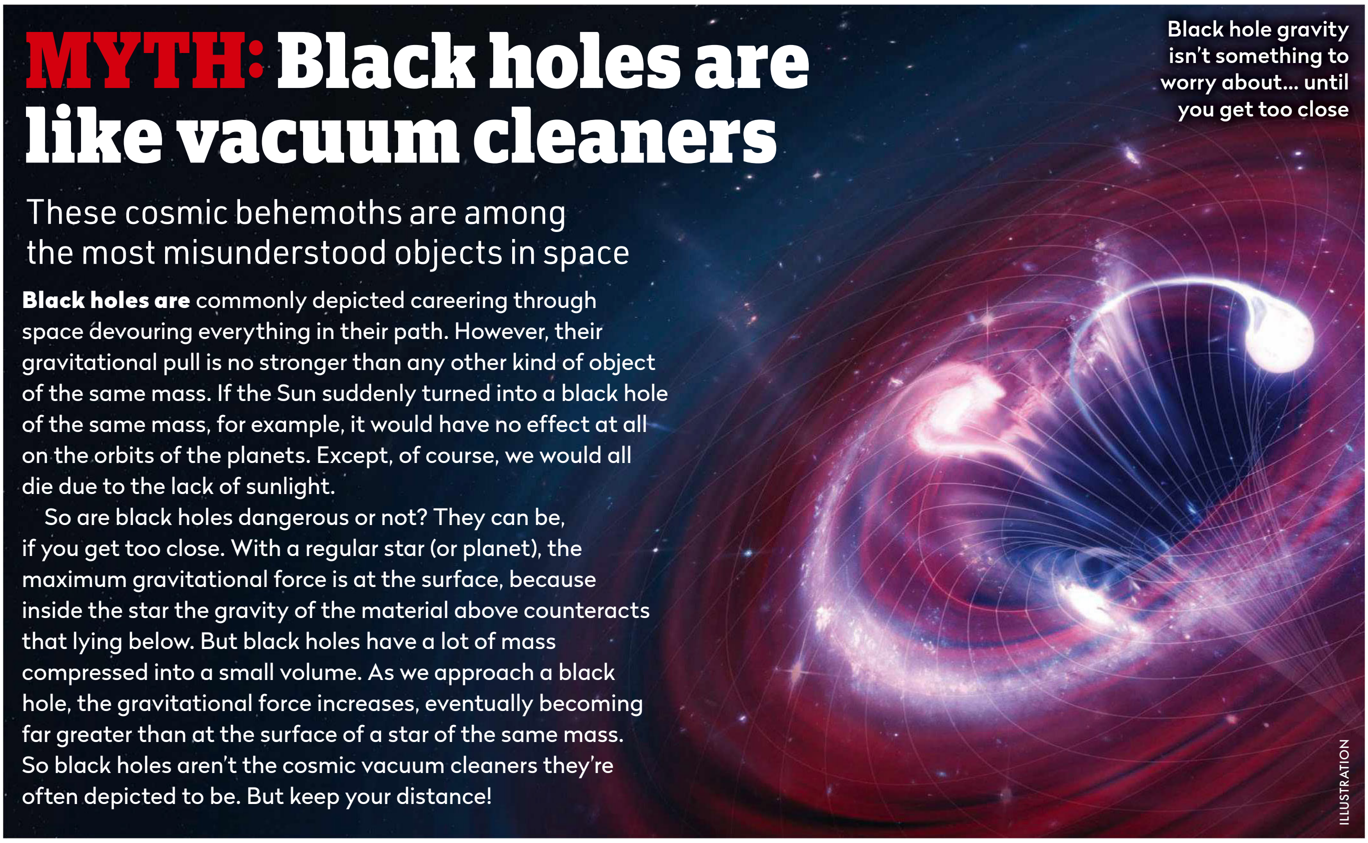
Albert Einstein's theory of relativity started with a simple fact: light always travels at the same speed, no matter how fast the light source is moving. This might not seem very odd, but it leads to a startling conclusion: the passage of time differs depending on your motion relative to others.

Let's try one of Einstein's thought experiments. You're in a moving train carriage and have placed torches at each end facing towards the centre. If you turned the torches on simultaneously, you would not be surprised to see the two light beams arrive at the centre at the same time.

If you had a friend who was watching from the station as the train passes by, they would see the two light beams travel at the same speed relative to them, but before the beams arrived at the centre, the train has moved. They would see the beam coming from the front of the carriage arrive first. To them, the beams do not arrive at the centre simultaneously.

How do two observers not agree on whether two events occurred simultaneously? Is our experiment wrong? No. It demonstrates that the passage of time is relative, not absolute. Time is not the same everywhere.

EARTH ORBIT ILLUSTRATION BY ADRIAN DEAN, URBAZON/GETTY, ALL ABOUT SPACE MAGAZINE/GETTY, ESO/M. KORNMESSER


Black hole gravity isn't something to worry about... until you get too close

MYTH: Black holes are like vacuum cleaners

These cosmic behemoths are among the most misunderstood objects in space

Black holes are commonly depicted careering through space devouring everything in their path. However, their gravitational pull is no stronger than any other kind of object of the same mass. If the Sun suddenly turned into a black hole of the same mass, for example, it would have no effect at all on the orbits of the planets. Except, of course, we would all die due to the lack of sunlight.

So are black holes dangerous or not? They can be, if you get too close. With a regular star (or planet), the maximum gravitational force is at the surface, because inside the star the gravity of the material above counteracts that lying below. But black holes have a lot of mass compressed into a small volume. As we approach a black hole, the gravitational force increases, eventually becoming far greater than at the surface of a star of the same mass. So black holes aren't the cosmic vacuum cleaners they're often depicted to be. But keep your distance!

MYTH: Earth-like planets are rare

Put your 'main character syndrome' aside – planets like ours could be a dime a dozen

As of now, astronomers have discovered over 5,800 exoplanets. The two main methods used to find these elusive distant worlds (the transit method and the radial velocity method) are more suited to discovering large exoplanets or those close to their host star. This means Earth-like exoplanets are hard to find.

Even so, one study concluded that 22 per cent of Sun-like stars have Earth-sized planets in their habitable zones. Even if this estimate is too high, there are so many stars in the Universe that the number of Earth-like exoplanets remains huge. One estimate suggests there may be 2.6 billion Earth-like exoplanets in our Milky Way Galaxy alone. And there are probably upward of 10 trillion galaxies in the Universe.

Our closest Earth-like exoplanet is Proxima Centauri b, orbiting the closest star to the Sun. If our nearest stellar neighbour hosts Earth's sister world, they can hardly be thought of as rare.

Not unique: at 5,800 planets and counting, there could be billions of Earth-like worlds

ILLUSTRATION

The fundamentals of astronomy for beginners

EXPLAINER

ILLUSTRATION

Do distant planetary systems have hundreds of moons like ours does? The hunt is on to find out

Exomoons

Astronomers have found thousands of planets orbiting other stars. Now they're on the cusp of discovering their moons too

In early April, NASA's James Webb Space Telescope completed its third observing programme, a nine-month-long roster of research proposed by astronomers around the world. Among the many groundbreaking projects in the infrared telescope's packed schedule was the most ambitious attempt so far to track down an entirely new class of alien world.

Exomoons, as the name suggests, are satellites of exoplanets. These worlds are tantalising for several reasons. Their discovery could tell us more about how planetary systems form and they could open up new ways to study the properties of their parent planets. Most intriguingly, they could vastly increase the number of potentially habitable worlds suitable for life to evolve.

Tracking down exomoons, however, is a challenge that pushes current technology to its limits. In 2018, astronomers found the first hint of an exomoon around the planet Kepler-1625b, but as yet neither this nor any other exomoon discovery has been confirmed. Most exoplanets are currently discovered using one of two methods. The radial velocity technique analyses stellar spectra to reveal shifts in their motion towards and away from Earth as they are tugged in different directions by a planet's gravity. The transit method, meanwhile, monitors the brightness of stars, looking for dips caused when an object passes in front of them and prevents some of their light from reaching our telescopes.

Giles Sparrow is a science writer and fellow of the Royal Astronomical Society

Detection difficulties

The traditional radial velocity method is no use when looking for moons, however, because it's impossible to distinguish between the influence of a planet with an orbiting moon and that of a slightly more massive solo planet. Hypothetically, it should be possible to discover moons using radial velocity measurements of light from exoplanets themselves, but this is far beyond the abilities of any current telescope.

The most promising way of finding exomoons is therefore to look in more detail at transits, searching for secondary dips in brightness caused when a satellite precedes or follows its planet across the face of its star.

There are several other possible techniques. Direct photographic imaging of an exomoon is feasible, but would be a long shot that's currently

CEMAGRAPHICS, RON MILLER/STOCKTREK IMAGES/GETTY, NASA/ ESA/D. KIPPING (COLUMBIA UNIVERSITY) AND A. FEILD (STSCI)

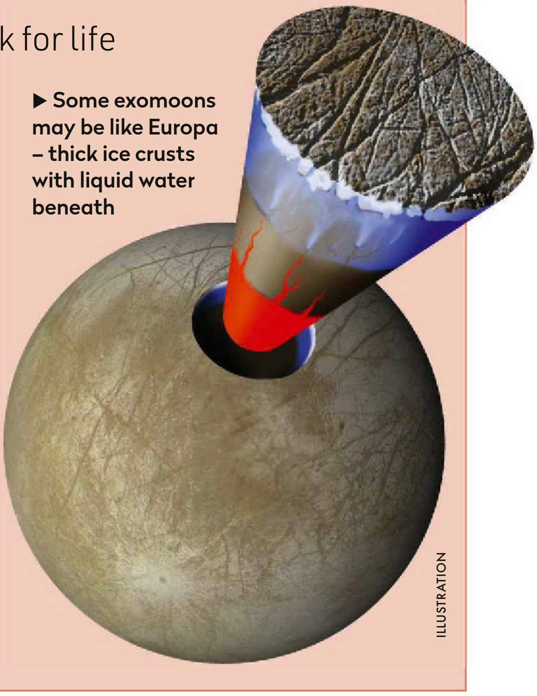
Habitable havens

Rock-and-ice moons could provide even more places to look for life

Confirming the existence of exomoons would be an exciting step forward in the search for life elsewhere in the Milky Way. According to recent estimates, about half of the Milky Way's Sun-like stars are likely to have rocky planets in their habitable zone, where the temperature range would allow liquid water to persist on the surface. However, truly Sun-like stars – classed by astronomers as G-type dwarfs – amount to only about 7 per cent of the Milky Way's 200 billion stars.

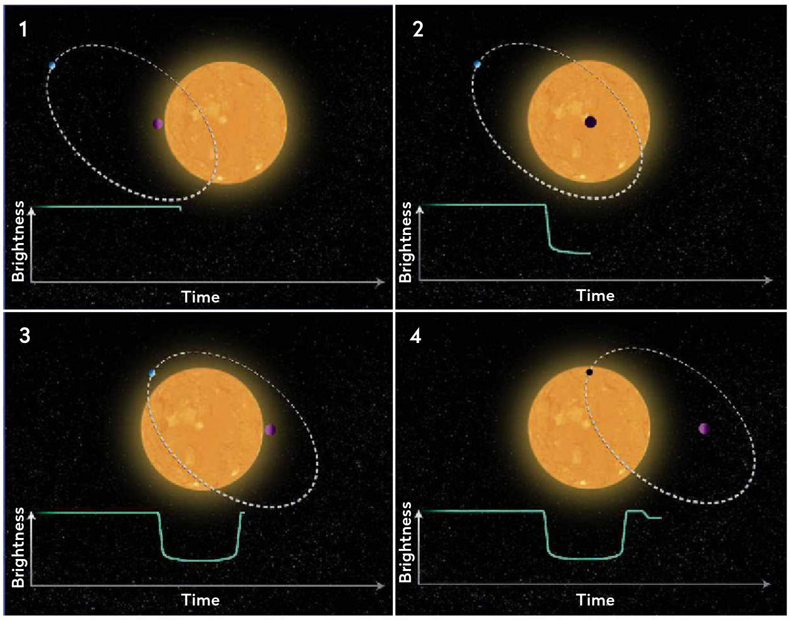
As well as these rocky worlds, significant numbers of Jupiter-like gas giants and related worlds are also found in habitable zones, but it's harder to imagine how life could get started inside these gassy, turbulent balls. If many of these giants turn out to have substantial moons, however, then habitable exomoons could potentially outnumber rocky planets.

What's more, giant planets could foster life-friendly conditions on exomoons in more hostile environments. Within our own Solar System, the ice-encrusted moons Europa and Enceladus (both well beyond the habitable zone) have substantial layers of liquid water heated by tidal interactions with Jupiter and Saturn respectively. Subterranean ocean layers of this kind on exomoons could even be shielded from threats such as the powerful stellar flares generated by red dwarf stars, which many scientists view as a substantial barrier to the evolution of life around these plentiful stars.



▶ Some exomoons may be like Europa – thick ice crusts with liquid water beneath

ILLUSTRATION



▲ Hubble detected a gas giant around the star Kepler-1625 in Cygnus from the dip in starlight as it transited. It then picked up a second, smaller dip 3.5 hours later – the signature of a moon as big as Neptune trailing behind the exoplanet

only practical for exomoons in the systems closest to Earth. Microlensing – where the gravity of an intervening planet or moon focuses light from a distant star towards Earth and causes its image to briefly brighten – could reveal a moon. However, the one-off nature of such alignments makes it almost impossible to confirm a suspected exomoon detected in this way. It's also possible to measure changes in the timing or duration of the planet's transits caused by the pull of its moon's gravity.

A great deal of the search for potential exomoons involves the careful analysis of data from dedicated transit-hunting satellites such as Kepler (operational from 2009 to 2018) and TESS (launched in 2018), which can monitor specific areas of the sky for long periods. JWST, however, has countless demands on its observing time, so its first exomoon search focused on detailed measurements of a single system.

Webb enters the game

The project, led by Ben Cassese of Columbia University and his supervisor David Kipping, involves a deep study of transits by a Jupiter-sized exoplanet (designated Kepler-167e), roughly 1,100 lightyears from Earth. "Kepler-167e is a particularly outstanding target," explains Kipping. "It's arguably the most Jupiter-like transiting exoplanet discovered to date."

The planet transits every 1,071 days, giving it an orbital period between that of Mars and Jupiter. The larger a planet's orbit, the less likely it will have the precise alignment to Earth needed for transits, but the more slowly it will move across its star and the more data can be obtained to potentially pin down an exomoon. During the transit in October 2024, JWST used its suite of instruments to measure Kepler-167e continuously over 60 hours. Cassese, Kipping and their colleagues are now busy crunching the data.

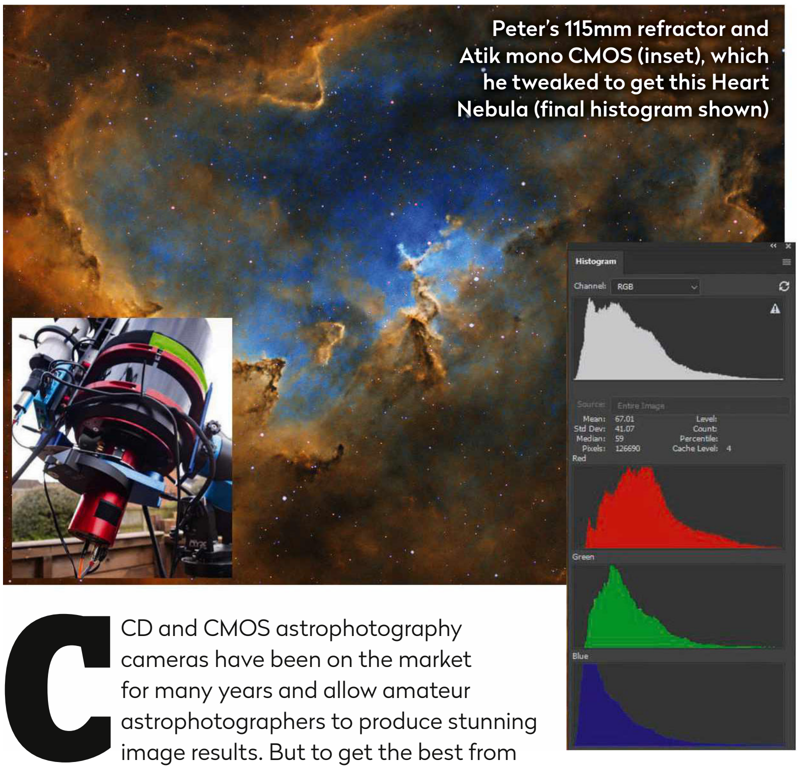
"JWST should be sensitive to moons as small as Ganymede and Callisto, that we know with certainty can form around Jupiter-like planets," says Kipping. "So this offers the first real test of the universality of how often such moons form in similar environments and hopefully paves the way to many more moon searches to follow with Webb."

Practical astronomy know-how for every level of expertise

SKILLS FOR STARGAZERS

Get the best from your astro camera

How to optimise your CCD or CMOS settings for great imaging results



Channel: RGB

Source: Entire Image

Mean: 67.01
Std Dev: 41.07
Median: 59
Pixels: 126690
Level:
Count:
Percentile:
Cache Level: 4

Peter's 115mm refractor and Atik mono CMOS (inset), which he tweaked to get this Heart Nebula (final histogram shown)

CCD and CMOS astrophotography cameras have been on the market for many years and allow amateur astrophotographers to produce stunning image results. But to get the best from your astro camera, you need to really understand and master its settings.

If you've just bought one or you've had one for a while but you're not getting the results you hoped for, it's time to learn all about it – and learn from examples of good (and bad!) imaging results. We'll run through how to judge your settings both during and after a 'first light' session. Much can also be learned in post-processing, meaning you can tweak settings on the next clear night.

There are four main settings to focus on: exposure, binning, gain and offset. Exposure is how long (in seconds) each frame is. Finding your camera's ideal exposure length depends upon many factors, including device sensitivity, sky conditions, light pollution and your astronomy target. Longer exposures can lead to more signal and detail, but also introduce noise. This could be system noise (created by the electronics) or shot noise. While system noise is reduced by taking calibration frames, shot noise can be reduced by taking multiple frames to stack together later. A careful examination of the histogram curve in your capture software will show if an exposure is too long or short. If the curve is fully towards the left axis, shadow detail may be lost in post-processing, whereas a curve that extends to the right will clip highlights, leading to blown-out areas.

ALL PICTURES: PETER JENKINS

Peter Jenkins is an astrophotographer and a fellow of the Royal Astronomical Society

Binning, gain and offset

The next consideration is your binning setting. In normal operation, each pixel acts on its own to record the photons hitting the sensor; this is known as 1x1 binning. Binning at 2x2, however, combines the output from four pixels, which provides an increase in sensitivity, but four times less resolution. You'd usually pick 2x2 binning to speed up the collection of colour data when using red, green and blue filters. Separate exposures binned at 1x1 through a luminance filter can then be used to provide the finer detail.

Camera gain is important for CMOS cameras and is usually given by the manufacturer as a number, called the 'unity gain'. This means that one electron produced by the sensor will be recorded as one digital unit. Changing gain is like turning up or down the number of electrons required to produce the same signal. Increasing gain results in less signal being required to activate a digital unit, but more noise and less dynamic range. While many CCD cameras have a gain setting, often they can't be changed. An incorrect gain setting is difficult to identify before processing your image. Look out for a tightly compressed curve on the temporarily stretched histogram during capture and lots of image noise once processed. An image taken with a high gain will look flat without a full range of tones. Start by using the manufacturer's recommended gain setting.

Finally, the camera offset setting determines the image's black level. Manufacturers normally quote an offset for their cameras. If the offset is set too low, dark blotches can appear in your image background.

What you'll need

- ▶ A cooled CCD or CMOS astrophotography camera
- ▶ A telescope to which the camera can be attached, with an adequate image circle to cover the dimensions of the camera sensor
- ▶ Control software for your mount and camera
- ▶ An equatorial mount
- ▶ Processing software

Step by step

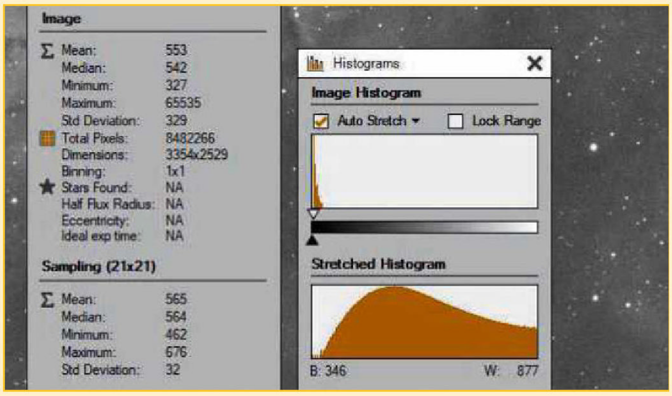


Image
Mean: 553
Median: 542
Minimum: 327
Maximum: 65535
Std Deviation: 329
Total Pixels: 8482266
Dimensions: 3354x2529
Binning: 1x1
Stars Found: NA
Half Flux Radius: NA
Eccentricity: NA
Ideal exp time: NA

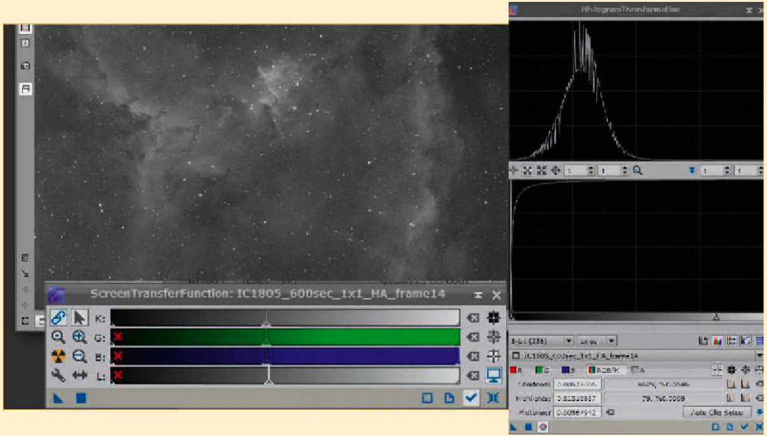
Sampling (21x21)
Mean: 565
Median: 564
Minimum: 462
Maximum: 676
Std Deviation: 32

Histograms
Image Histogram
☑ Auto Stretch
☐ Lock Range
Stretched Histogram

B: 346 W: 877

Step 1

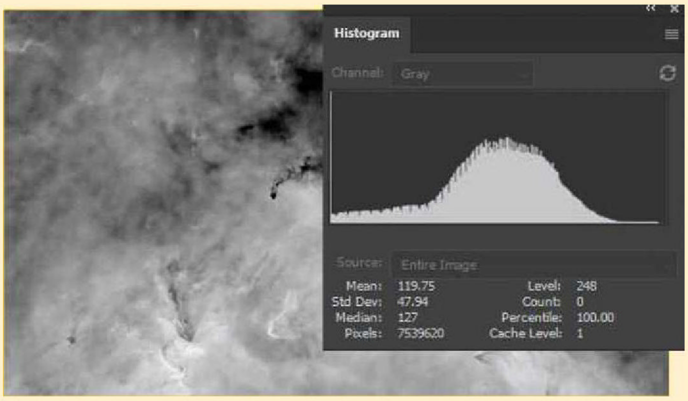
Most image-capture software provides a temporary stretched image. Check the histogram: the left of the curve should show a small gap between it and the left axis, otherwise darker areas will be clipped. Changing the offset setting adjusts this gap.



HistogramTransformation
ScreenTransferFunction: IC1805_600sec_1x1_HA_frame14
K:
G:
B:
L:
Shadows:
Highlights:
Midtones:
Auto Clip Setup

Step 2

You can also check your offset setting when processing. Here is the Screen Transfer Function in PixInsight. The histogram (top right) shows a gap from the left axis; the bottom menu shows the rest of the image is adequately spread between the other tones.

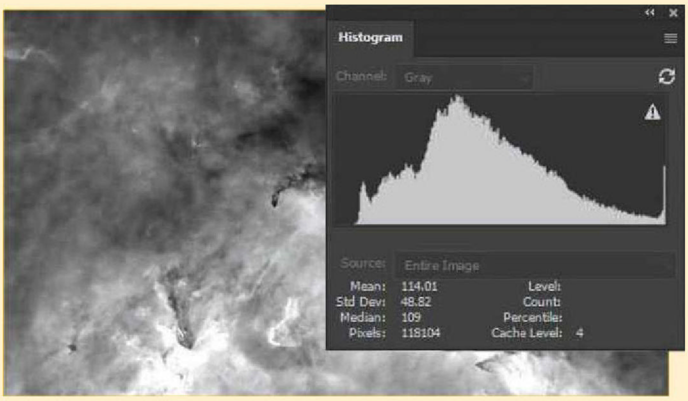


Histogram
Channel: Gray

Source: Entire Image
Mean: 119.75
Std Dev: 47.94
Median: 127
Pixels: 7539620
Level: 248
Count: 0
Percentile: 100.00
Cache Level: 1

Step 3

Here the curve is shifted too far to the left (extending beyond the left axis). The image suffers from loss of detail in the darker areas. If you see this in your test images, change your offset in the capture software to move the curve further to the right.

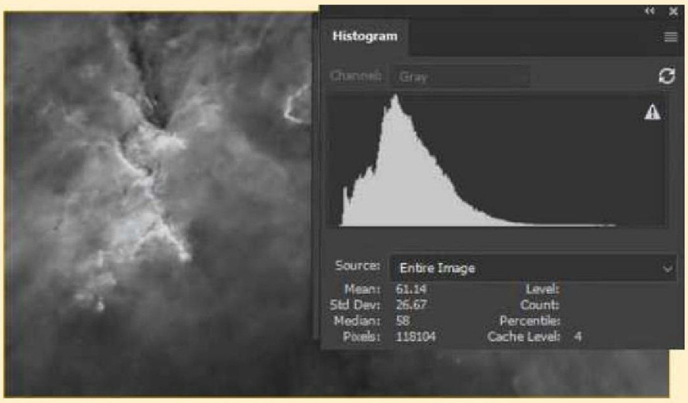


Histogram
Channel: Gray

Source: Entire Image
Mean: 114.01
Std Dev: 48.82
Median: 109
Pixels: 118104
Level:
Count:
Percentile:
Cache Level: 4

Step 4

This curve is too far to the right (extending beyond the right axis) leading to burnt-out highlights (lower left). Shorter exposures are required. This is particularly important when imaging galaxies where the core may burn out even with fairly short exposures.

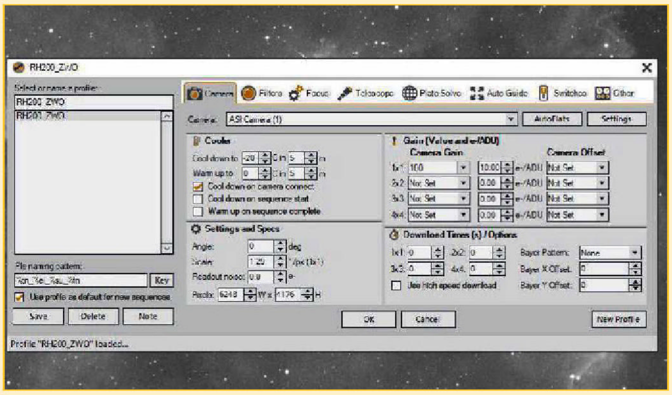


Histogram
Channel: Gray

Source: Entire Image
Mean: 61.14
Std Dev: 26.67
Median: 58
Pixels: 118104
Level:
Count:
Percentile:
Cache Level: 4

Step 5

These principles also apply to narrowband data; above is from an Ha frame. A visual assessment of the image confirms there are subtle dark tones and detail in the light areas, meaning no details are clipped. This implies that our camera settings are correct.



RH200_ZWO
Select or name a profile:
RH200_ZWO
RH201_ZWO
Camera
Filters
Focus
Telescope
Plate Solve
Auto Guide
Switches
Other
AutoFlats
Settings
Cooler
Settings and Specs
Gain (Value and e-/ADU)
Download Times (s) / Options
Save
Delete
Note
OK
Cancel
New Profile

Camera: ASI Camera (1)
Cool down to -20 C in 5 m
Warm up to 0 C in 5 m
☑ Cool down on camera connect
☐ Cool down on sequence start
☐ Warm up on sequence complete
Angle: 0 deg
Scale: 1.20 "/px (1x1)
Readout noise: 0.0 e-
Pixels: 6248 W x 4176 H
Camera Gain / Camera Offset
1x1: 100 10.00 e-/ADU Not Set
2x2: Not Set 0.00 e-/ADU Not Set
3x3: Not Set 0.00 e-/ADU Not Set
4x4: Not Set 0.00 e-/ADU Not Set
1x1: 0 2x2: 0
3x3: 0 4x4: 0
☐ Use high speed download
Bayer Pattern: None
Bayer X Offset: 0
Bayer Y Offset: 0
File naming pattern: %n_%e_%su_%n
☑ Use profile as default for new sequences
Profile "RH200_ZWO" loaded...

Step 6

While processing your first-light images, note the settings you'd like to tweak. Gain and offset are then changed in your capture software, eg Equipment Profile Manager in SGPro. Exposure and binning settings can be changed in the image-sequence section.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Demystifying the Moon illusion

An apparently supersized Moon low on the horizon fools the eye... but not the camera

When the full Moon occurs near the horizon, it looks artificially massive. Even if you've been into astronomy for a long time, this can still catch you out, convincing you that that low-down full Moon, or near-to-full Moon, is indeed larger than it should be. But this is false, an illusion conjured up by our brains. This month's Capture shows you how to debunk the illusion.

While our brains have trouble *not* seeing the Moon as huge when it's near the horizon, a camera isn't fooled at all. This is especially true when you see a low full or gibbous Moon near the horizon and try to capture its apparently massive appearance with a smartphone. The resulting image shows nothing particularly impressive. The camera can't see the illusion, so it doesn't record it.

In order to debunk what you're seeing, you'll need to attempt to capture a regular full Moon high in the sky. Devoid of any horizon references, this full Moon will provide the control image. Then, you'll have to attempt to capture the full or large waning gibbous Moon when it's low down, either just after rising or just before setting. Comparing the two images will give you the ammunition you need to debunk the illusion.

▲ The rising or setting full or gibbous Moon can look huge to our eyes, but follow our walkthrough to reveal how it's all an illusion

Like for like

But are all things equal? When the Moon is high in the sky and due south, this is when it's closest to you on the surface of Earth. The smallest distance occurs when there's a straight line connecting the centre of Earth, you and the Moon. When the Moon is low on the horizon, the distance is slightly greater, by approximately an Earth radius. Consequently, the low 'massive' Moon should appear, if anything, a tiny bit smaller than the high-up 'regular' Moon.

Then there's atmospheric refraction to take into account. Near the horizon, this squashes the apparent vertical dimensions of an extended object slightly, so the full Moon looks like a squashed oval, as is also the case with the rising or setting Sun. As well as the more distant low-altitude Moon having a smaller apparent size than one high up, it's also squashed vertically too.

To take the comparison shots under fair conditions, it's also important to try to capture the low and high Moon on the same night. If not, there are also orbital variances that need to be taken into account, as a perigee full Moon has a larger apparent diameter than an apogee full Moon.

Of course, this experiment is at the mercy of the weather, but catching the two images within a 2–3-month period should be fine. Image scale makes a big difference too. A small scale, such as you'd achieve using a smartphone, allows you to generally show that the Moon illusion isn't real. However, a medium image scale, such as you'd achieve using a small telescope with a high-frame-rate camera, gives you enough information to directly measure the effects, making a measurement of the apparent diameter of the low and high Moons. This will make a great record for when you next encounter the Moon illusion with someone who's never noticed it before. Now you can say with confidence that it's not real!

Equipment: Any camera that can image the Moon as a disc

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

✉ **Send your images to:**
gallery@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

Step by step

STEP 1

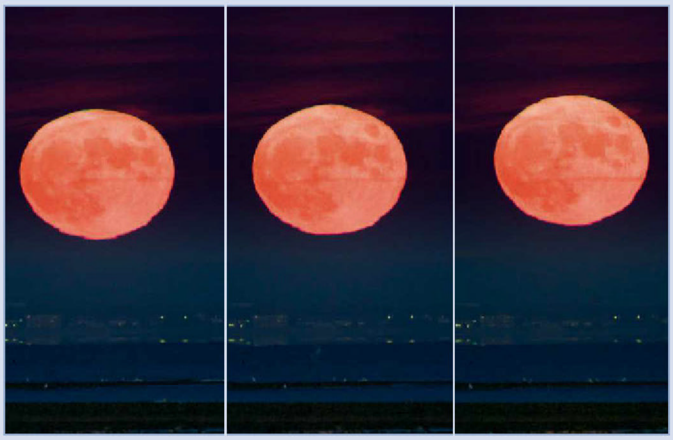
For the best effect, catch the full Moon or the gibbous Moons that appear for several days either side of it. Waxing gibbous Moons need to be caught before moonset in the morning, waning gibbous Moons just after moonrise in the evening. The full Moon appears near the horizon in evening or dawn twilight.

STEP 2

Plan how you're going to capture the Moon. A low-tech option using a smartphone is okay, as long as you can show the Moon as a disc with some foreground in view. Here, twilight conditions can help, making it easier to capture the foreground and the Moon in the same shot while avoiding over-exposure.

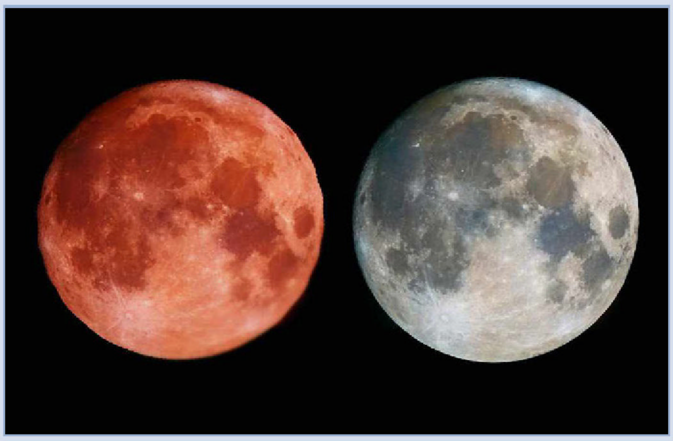
STEP 3

If you use something with a bit more magnification, such as a DSLR or equivalent with a telephoto lens, if you're quick you still can capture the Moon plus foreground. June's very low full Moon should be ideal for this, only achieving around 8° altitude when due south as seen from the centre of the UK.



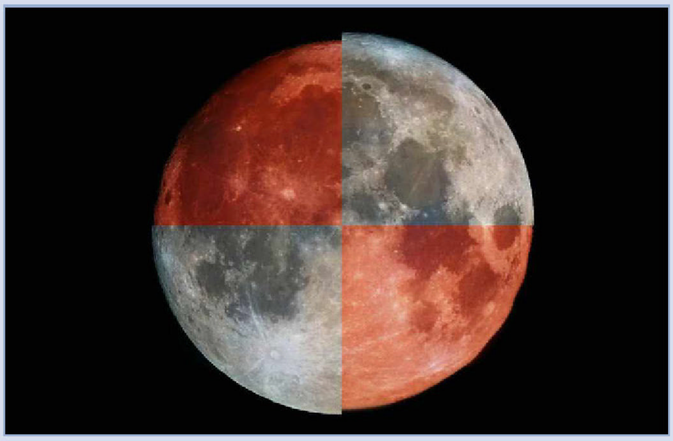
STEP 4

Image the Moon so it appears bright but with no areas of over-saturation, avoiding any areas that appear pure white. Wait for the Moon to fully rise then focus as accurately as you can as this will provide the best limb for comparison. Take several images in case poor seeing or wind causes edges to blur.



STEP 5

Larger image scales can capture the entire Moon's disc when it's low down and again when it's higher in the sky. Use the same kit to take both shots and load the results as separate layers in a layer-based editor. Align both images so the centre of each Moon is in the centre of the image and they show the same orientation.



STEP 6

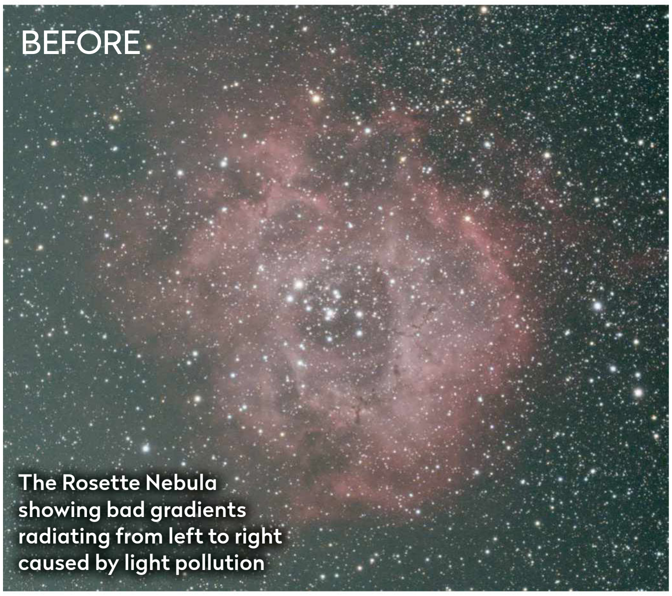
Alternatively, duplicate the base images as a second pair. Place the high-up Moon image on top and remove the upper-left and lower right quadrants. This gives a result that allows you to compare the horizontal and vertical dimensions of both results. How does the apparently 'massive' low Moon compare now?

Expert processing tips to enhance your astrophotos

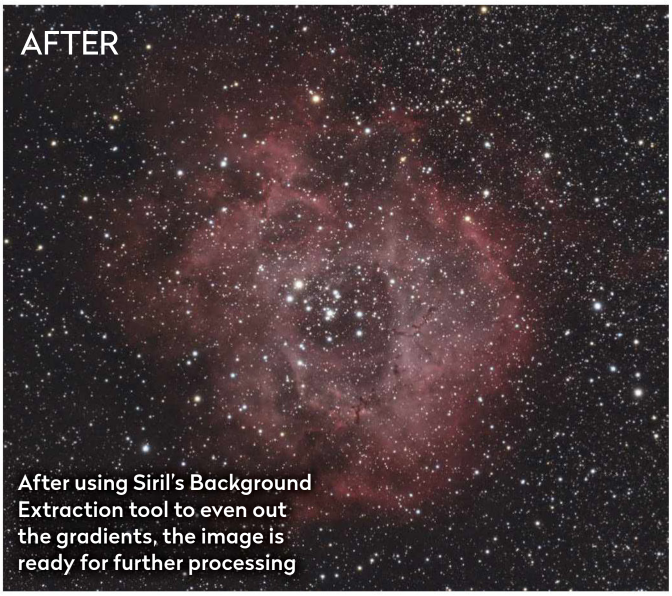
ASTROPHOTOGRAPHY PROCESSING

Stop light pollution spoiling your shots

Improve your nebula images with a free gradient-removal tool


BEFORE

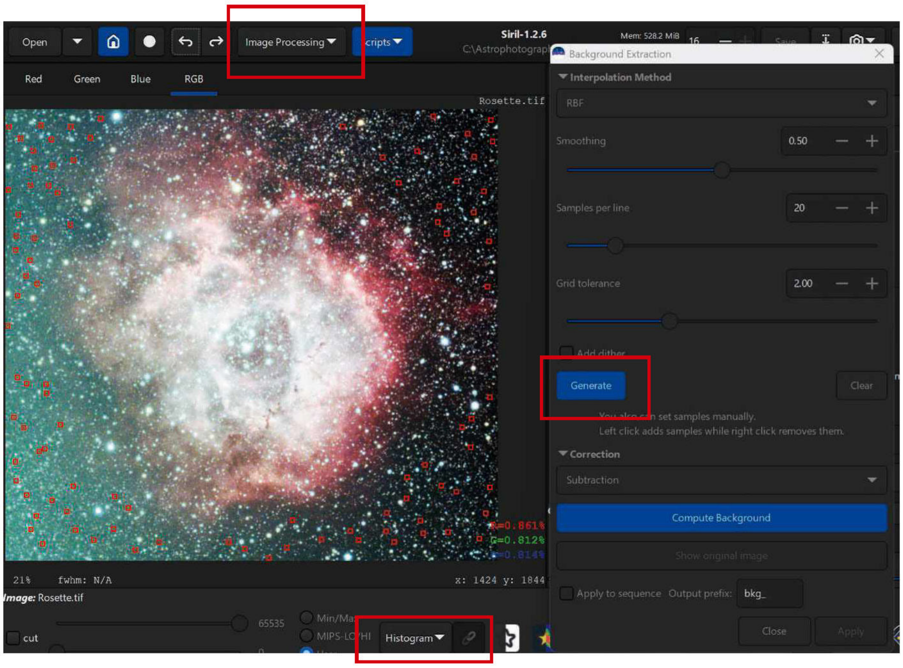
The Rosette Nebula showing bad gradients radiating from left to right caused by light pollution


AFTER

After using Siril's Background Extraction tool to even out the gradients, the image is ready for further processing

For astrophotographers, gradients are a common problem, even if photographing from a dark site. Caused by light pollution, either from artificial lighting or Moon glow, they make backgrounds look uneven and can particularly affect faint targets like nebulae. They can become more obvious when you stack your frames, detracting from fainter details. Thankfully, there are options to help.

Siril is a powerful, free processing program with a built-in gradient-removal tool called Background Extraction. It's best to remove gradients after stacking your image, before any stretching or processing. We'll therefore start with a freshly stacked image of the Rosette Nebula made from 105 sub-frames. If your stacked result shows artefacts on the edges, it's best to crop the image before using Background Extraction.


Open
Image Processing
cripts
Siril-1.2.6
C:\Astrophotograp
Mem: 528.2 MiB
Red
Green
Blue
RGB
Rosette.tif
Background Extraction
Interpolation Method
Add dither
Generate
Clear
Correction
Compute Background
Show original image
Close
Apply
R=0.861%
G=0.812%
B=0.814%
Min/Max
MIPS-LO/HI
Histogram
cut
65535
0

Interpolation Method
RBF

Smoothing 0.50

Samples per line 20

Grid tolerance 2.00

You also can set samples manually.
Left click adds samples while right click removes them.

Correction
Subtraction

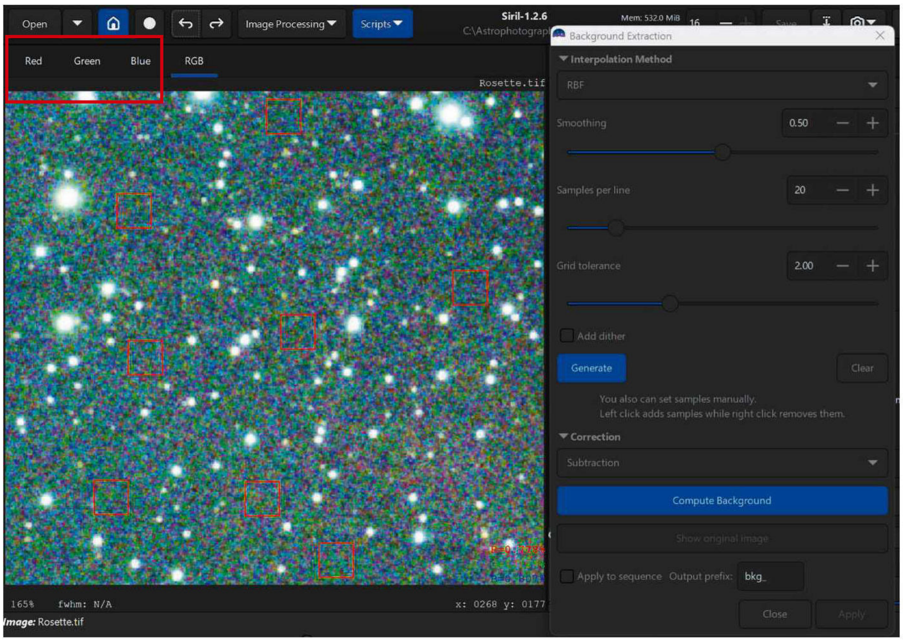
☐ Apply to sequence Output prefix: bkg_

21% fwhm: N/A x: 1424 y: 1844

Image: Rosette.tif

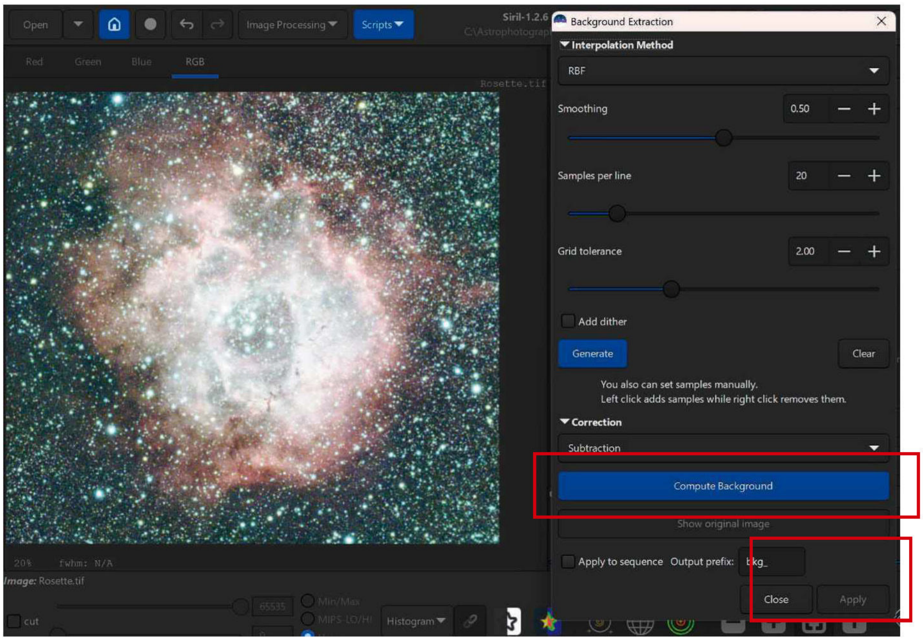
▲ Screenshot 1: open the Histogram view; this makes any light pollution far more obvious. Open Background Extraction and place points to select the background to be corrected

ALL PICTURES: IVANA PERANIC



Interpolation Method: RBF
Smoothing: 0.50
Samples per line: 20
Grid tolerance: 2.00
☐ Add dither
You also can set samples manually.
Left click adds samples while right click removes them.
Correction: Subtraction
☐ Apply to sequence Output prefix: bkg_

▲ **Screenshot 2: zoom in for better control as you place your points, to ensure you don't cover any stars or nebulosity. Checking the view in the red, green and blue layers will help**



Interpolation Method: RBF
Smoothing: 0.50
Samples per line: 20
Grid tolerance: 2.00
☐ Add dither
You also can set samples manually.
Left click adds samples while right click removes them.
Correction: Subtraction
☐ Apply to sequence Output prefix: bkg_

▲ **Screenshot 3: click 'Compute Background'. Siril will generate a corrected image you can adjust further if needed. Once you're happy, click 'Apply' to make the changes permanent**

To see the level of gradient you're working with, choose 'Histogram' in the bottom-middle menu (see Screenshot 1). This will show an extremely stretched version of the image. This is a preview only and any changes won't be permanently applied. Now click the 'Image Processing' tab on the top menu and select 'Background Extraction'.

In the Background Extraction menu, there are several controls that will help perform the best background extraction according to the specific gradient in your image. The first options are 'Polynomial' or 'RBF' (radial basis function) extraction. Polynomial, with its strength options from 1 to 4, is recommended for very simple gradients. However, since most gradients tend to rotate and overlap as your target moves across the sky, RBF is often the best option.

Select the background

The next three sliders allow you to automatically place a grid of points that determine the background in the image. The 'Smoothing' parameter controls the level of transition between these points. 'Samples per line' allows you to choose the number of points automatically generated in a horizontal line. 'Grid tolerance' defines whether a sample point will be placed in an area of the image; the lower the tolerance, the more a bright area will be designated as detail and not background.

Once these sliders are set, clicking 'Generate' will automatically place the points. If your nebula only covers a small portion of the image, adding points automatically can be time-saving; just make sure the points stay well clear of nebulosity and bright stars. If you misplace a point, remove it with a right click.

However, if the nebula covers a lot of the frame, you can add the points manually. In my example, I captured the Rosette Nebula from a Bortle 4 site on the South Downs. Despite the dark skies, there was a strong glow from Brighton's city lights, revealed by the histogram preview. Since the nebula took most of the frame, I added points manually.

Starting in the corners away from the nebula, zoom in and left-click to place points to designate as background (see Screenshot 2). If it becomes difficult to distinguish which bits to avoid, cycle through the R, G and B layers in the upper tab, or switch from 'Histogram' to 'Autostretch' mode for a temporary, less aggressive stretch of the image.

As you get closer to the target, less is more. You can add more points later if needed, but first you want to ensure you place points only on the background. When the points have been placed, clicking 'Compute Background' will create an image with a corrected background. This is not permanently applied to the image, so you can take away or add more points if more correction is needed. Once happy with your result, click 'Apply' (see Screenshot 3) and view the finished result in Autostretch mode.

3 QUICK TIPS

1. If the brighter side of the gradient is too bright, place the points using Autostretch view.

2. Right-click the same point twice to remove it and its two closest points in a single move.

3. You can perform background extraction more than once, so be conservative when placing your first points.

Ivana Peranic is a cellist by day and an astrophotographer by night, based in Brighton, UK

Your best photos submitted to the magazine this month

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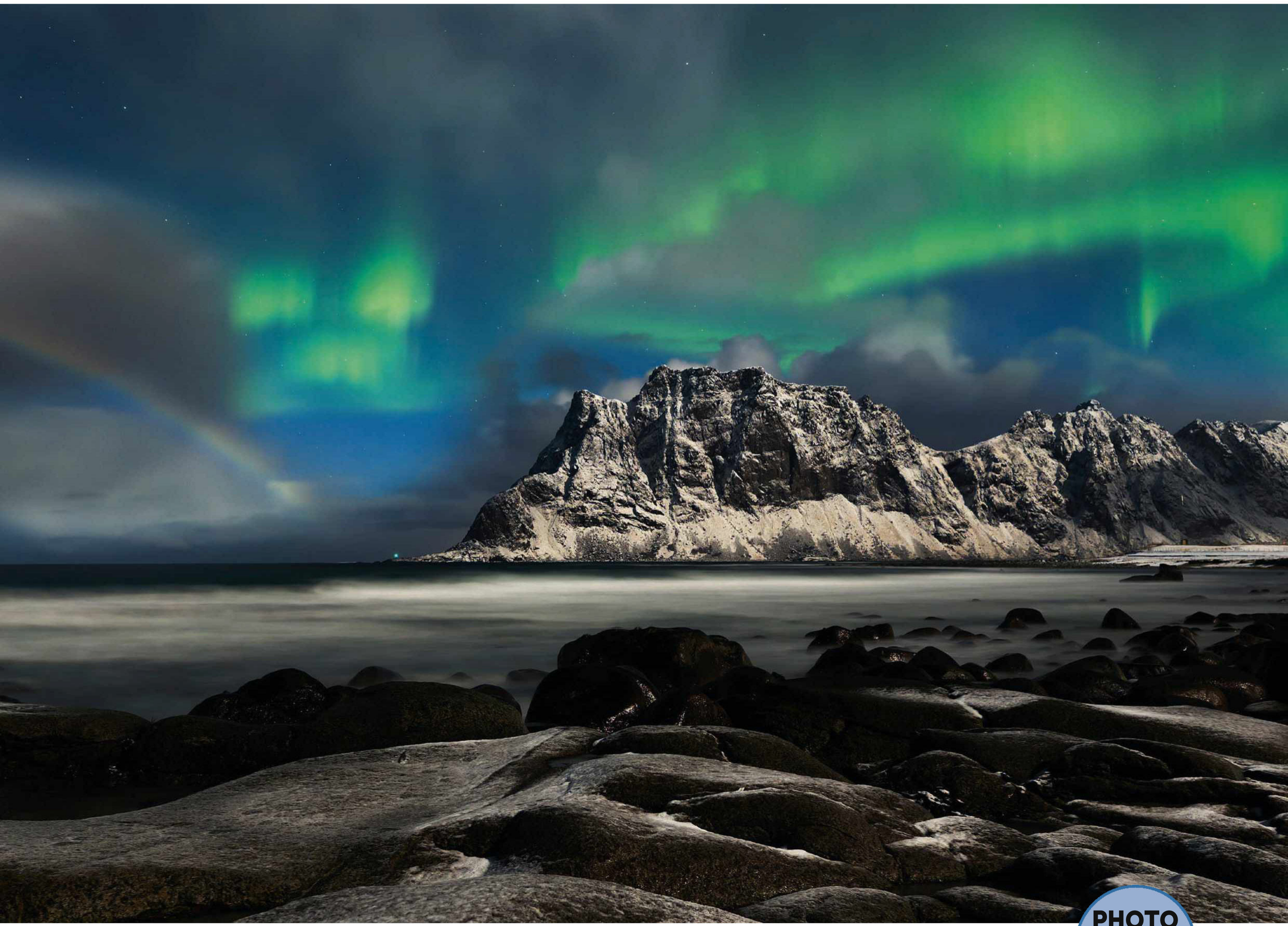


PHOTO OF THE MONTH

△ Aurora borealis

Alessandro Scalas, Lofoten Islands, Norway, 12 February 2025

Alessandro says: "The sky was cloudy, but then it opened up and started to turn green, and I was amazed to see a moonbow reflecting the light of the full Moon behind me. It was a fantastic experience, despite the extreme cold!"

Equipment: Nikon Z7 II camera, Nikkor Z 14–30mm lens, Leofoto Ranger LS-254C tripod
Exposure: ISO 3200 f/4.0, 6"
Software: Camera Raw

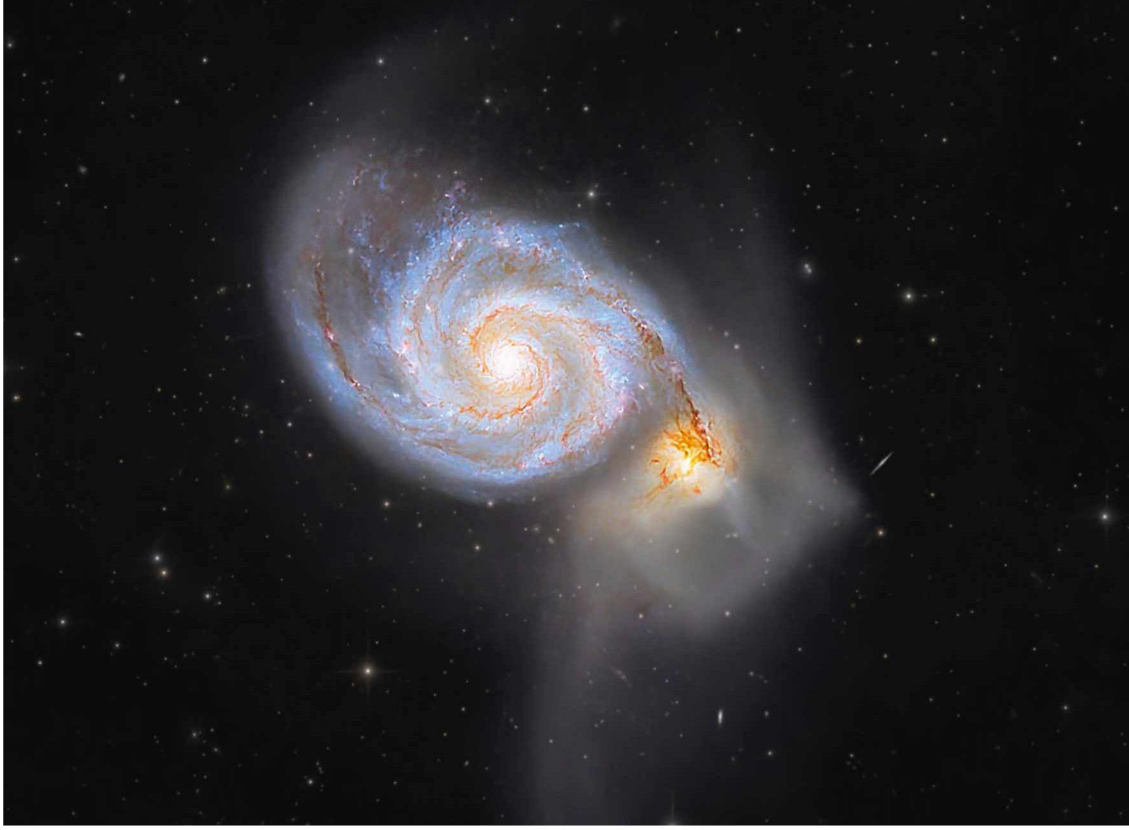
Alessandro's top tips: "Travel, have fun and take pictures! Plan your adventures, choose the spot to photograph and check the weather carefully. And if sometimes the sky offers only bad jokes, don't despair – there is often a surprise in store, as happened to me when the cloudy skies opened and gave us this spectacle of nature. So be tenacious!"

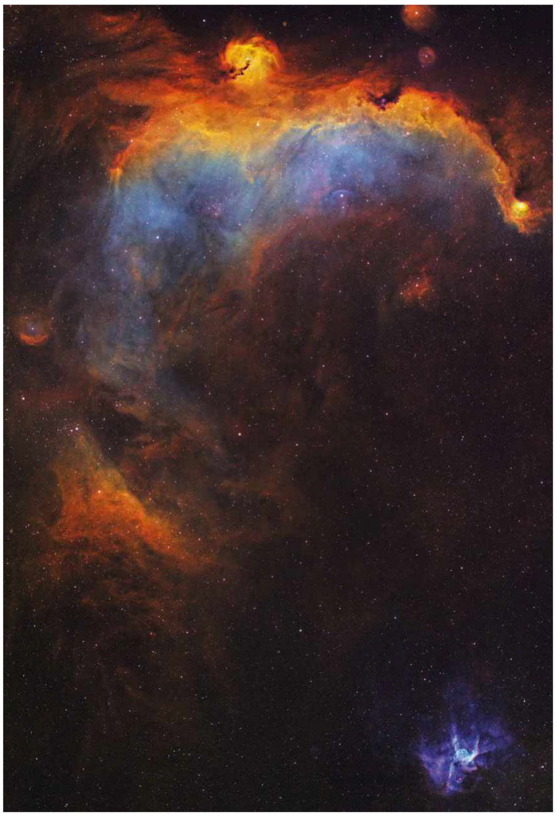
The Whirlpool Galaxy ▷

David Hugill, Cirencester, Gloucestershire, 2 and 3 March 2025

David says: "I find the Whirlpool Galaxy interesting due to its interaction with its close neighbour NGC 5195. Two very cold nights and 15 hours of usable data gave me a pleasing result."

Equipment: ZWO ASI585MC Pro camera, StellaLyra RC6 Ritchey–Chrétien, ZWO AM3 mount
Exposure: 225x 240"
Software: PixInsight





△ The Seagull Nebula and Thor's Helmet

Juan Paulo González, Atenguillo, Jalisco, Mexico, 27 February–2 March 2025

Juan says: "I'd shot these two objects separately before, but I wanted to capture them in a single frame – and at Astrophotography Weekend 2025 in Jalisco I managed to achieve just that!"

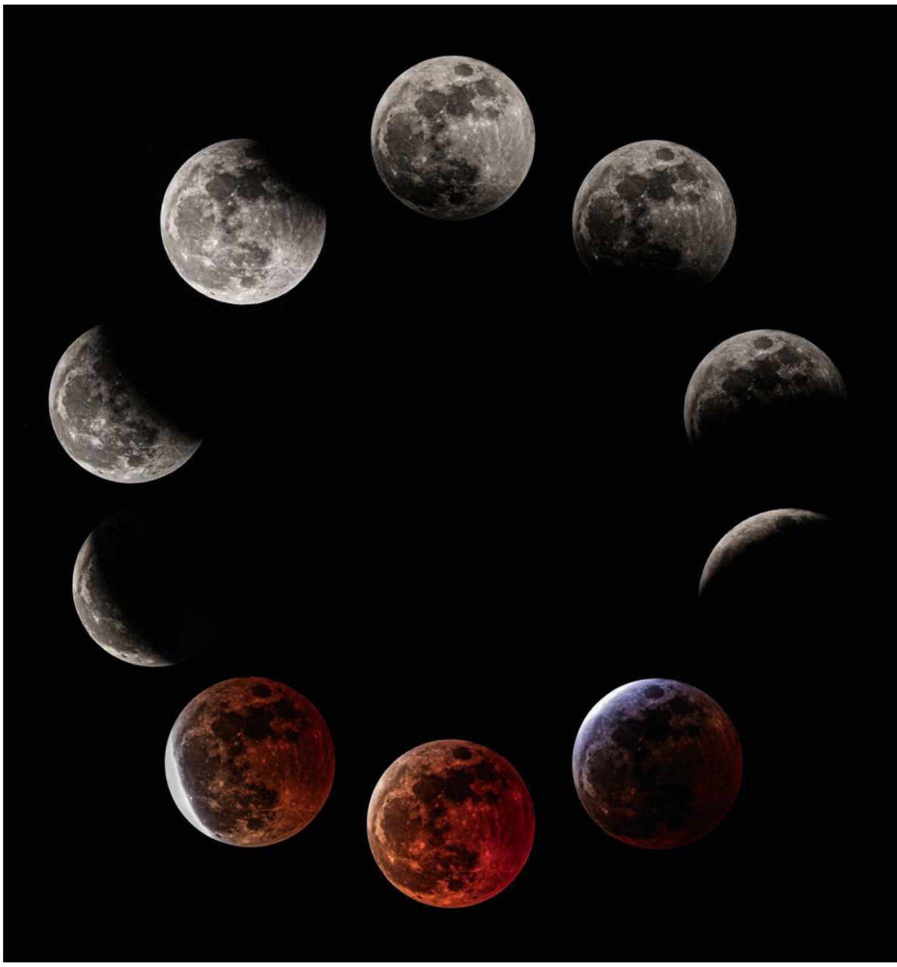
Equipment: ZWO ASI2600MM Pro camera, Takahashi FS-60CB refractor, Celestron Advanced VX mount
Exposure: Ha 82x 180", SII 52x 180", OIII 53x 180"
Software: Astro Pixel Processor, PixInsight

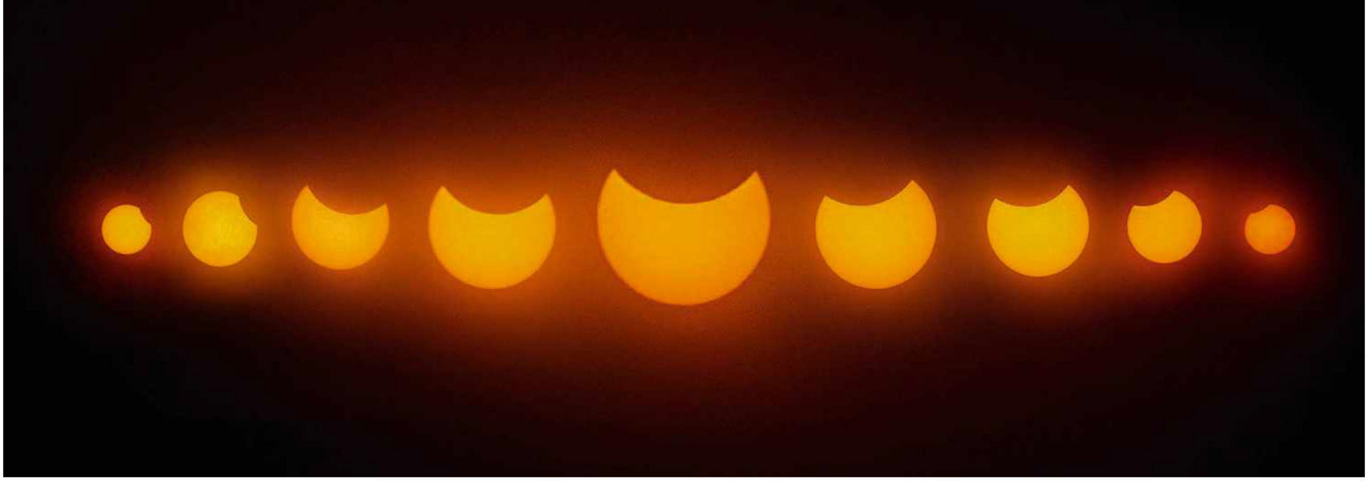
▽ Lunar eclipse

Greg Meyer, Painted Rock Petroglyph Site, Arizona, USA, 13 March 2025

Greg says: "It was overcast and had been extremely windy some hours before, but the Astrospheric weather app predicted clear skies for the eclipse and it was right!"

Equipment: Canon EOS 6D MkII camera, Sigma 150–600mm lens, ZWO AM5 mount **Exposure:** ISO 500 f/5.6, 1ms
Software: Lightroom, Photoshop





△ Partial solar eclipse

Rebecca Saxton, Cambridge, Cambridgeshire, 29 March 2025

Rebecca says: "The partial eclipse lasted for nearly two hours and I wanted to document the whole event, so a composite was the best medium."

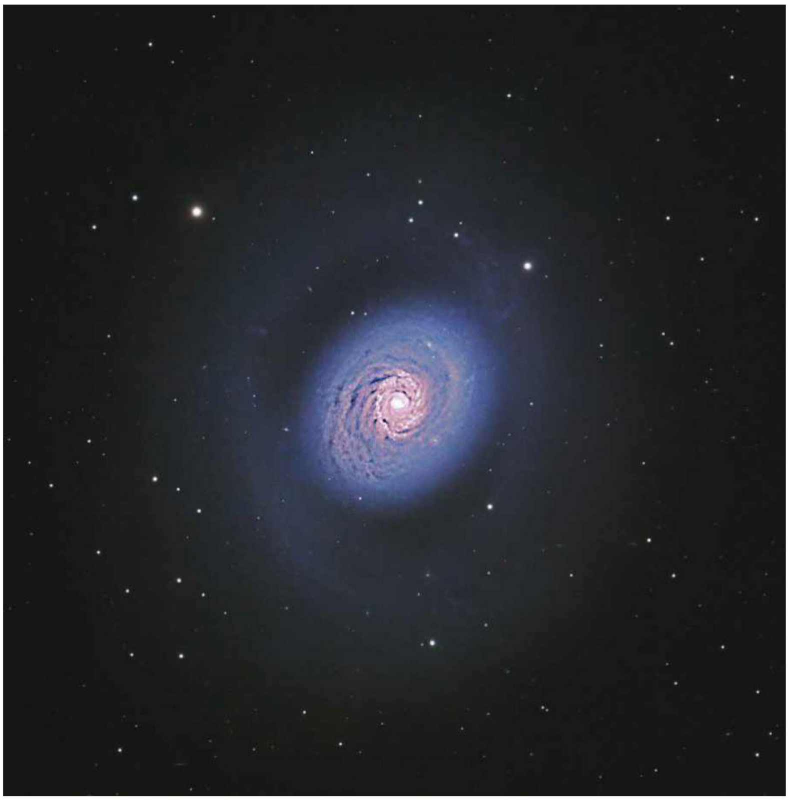
Equipment: Canon EOS 6D camera, Canon 70–200mm lens, K&F Concept 64 tripod
Exposure: ISO 200 f/4, 1/80"
Software: Lightroom, Photoshop

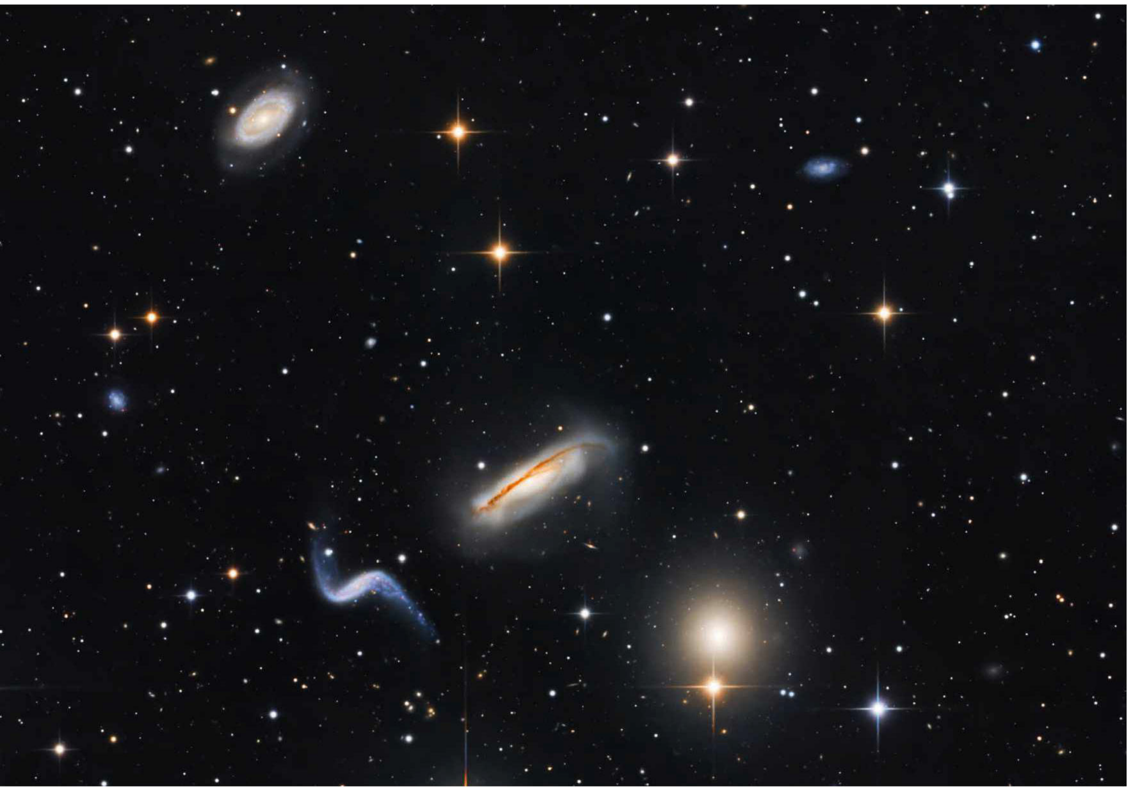
The Croc's Eye Galaxy ▷

Tim Jackson, Cheltenham, Gloucestershire, 27 February 2025

Tim says: "I wanted to capture the unusual halo surrounding M94's main structure. Due to the UK weather, I only managed 3.5 hours of data, but using the powerful tools in PixInsight I was able to resolve both the halo and the core."

Equipment: ZWO ASI2600MC Pro camera, Askar FRA500 refractor, ZWO AM5 mount
Exposure: 42x 300" **Software:** PixInsight



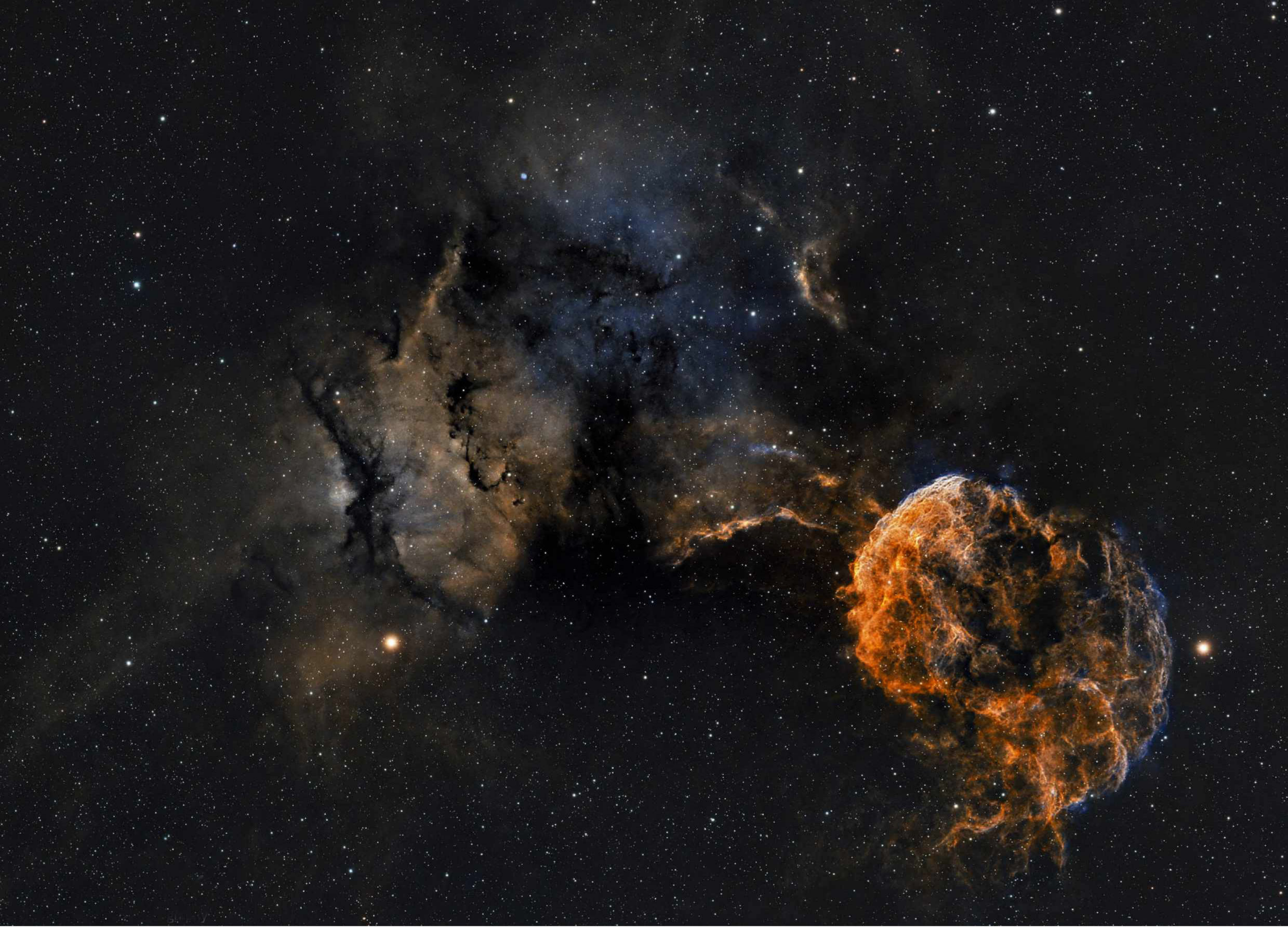


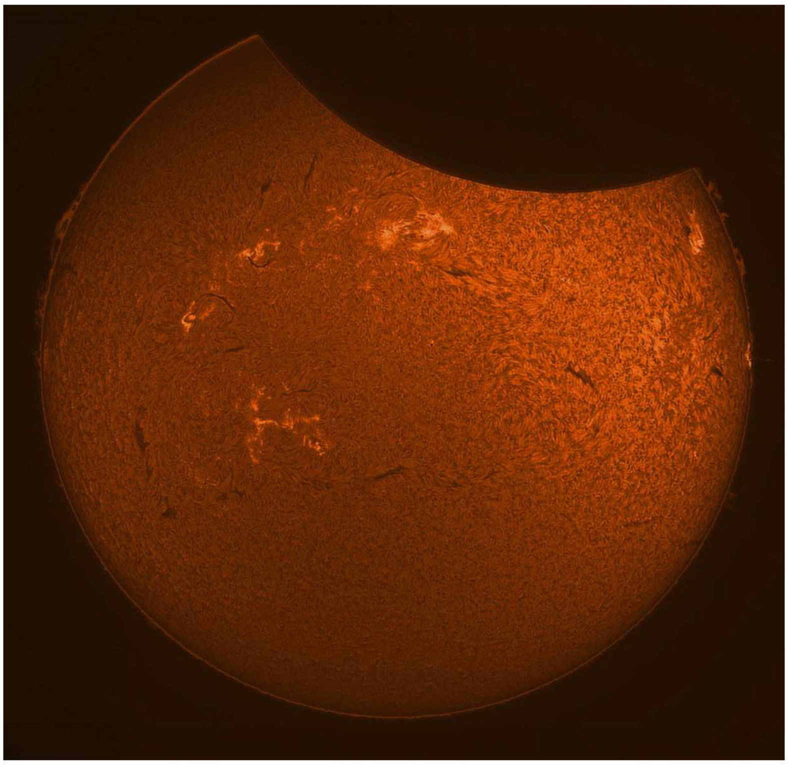
◁ Galaxy group Hickson 44

Massimo Di Fusco, captured remotely via Hellas-Sky, Greece, 27 February 2025

Massimo says: "Look closely and you can see a faint halo around NGC 3190 (centre) and also a subtle smudge between NGC 3190 and elliptical galaxy NGC 3193 (centre right), which is actually a bridge of stars being shared between the two giants."

Equipment: QHY600M camera, PlaneWave CDK17 astrograph, 10Micron GM3000 mount
Exposure: L 66x 180", R 105x 180", G 94x 180", B 94x 180", Ha 76x 180"
Software: Astro Pixel Processor, PixInsight, Photoshop





△ The Jellyfish Nebula

Steven Hill, Swansea, February–March 2025

Steven says: "This is a relatively easy target to image, and I was pleased with the result. The nebula's size required a widefield image to capture its intricate detail and molecular composition."

Equipment: ZWO ASI2600MC Duo camera, William Optics RedCat 61 refractor, ZWO AM5 mount
Exposure: RGB 60x 60" each, Ha/OIII 48x 300", SII/OIII 48x 300" **Software:** PixInsight, Lightroom, Photoshop

◁ Partial solar eclipse

Lee Davis, Westward Ho!, Devon, 29 March 2025

Lee says: "The clouds parted just long enough for me to capture this image. I was quite pleased with the result given the conditions, with plenty of active regions and some nice prominences on the limb."

Equipment: ZWO ASI178MM camera, Lunt LS50THa solar scope, Celestron Evolution NexStar 8 mount
Exposure: 770x 12.5ms video frames (best 100)
Software: AutoStakkert!, ImPPG, GIMP

ENTER YOUR IMAGE

Whether you're a seasoned astrophotographer or a beginner just starting out, we'd love to see your images. Send them to us at www.skyatnightmagazine.com/send-us-your-astrophotos

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Seestar
S30
OUT OF THIS WORLD AND INTO THE NEXT
Notes from a Physicist on Space Exploration
ADRIANA MARAIS
ECLIPSMART

86

Seestar's nifty S50 has won a lot of fans, but will the cheaper, smaller S30 top it? Read our review to find out

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★☆ Very good
★★★☆☆ Good ★★☆☆☆ Average ★☆☆☆☆ Poor/avoid

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@THESHED/PHOTOSTUDIO

Our experts review the latest kit

FIRST LIGHT

ZWO Seestar S30 smart telescope

Sure to tempt beginners, the S50's tiny sibling is afforable, super-simple and great fun

WORDS: SARAH PEASGOOD

VITAL STATS

- **Price** £369
- **Optics** Triplet apo refractor
- **Aperture** 30mm
- **Focal length** 150mm, f/5
- **Sensor** Sony IMX662 STARVIS 2
- **Resolution** 1,080 x 1,920 (tele), 1,920 x 1,080 (wide)
- **Mount** Altaz
- **Power** 6,000mAh battery
- **Storage** 64GB internal eMMC
- **Ports** USB-C
- **Connectivity** Wi-Fi, USB-C, Bluetooth
- **App control** Seestar iOS/Android app
- **Extras** Solar filter, carry case, tabletop tripod, USB-C cable
- **Weight** 1.65kg; 1.80kg with tripod
- **Supplier** 365Astronomy
- **Tel** 020 3384 5187

ALL PICTURES: @THESHED/PHOTOSTUDIO

The latest Seestar model has been released by ZWO and despite the rumour mill predicting it would be a larger successor to the popular Seestar S50, the new kid on the block is smaller. The Seestar S30 is a 30mm smart telescope designed for ultra-portability and provides a wider field of view.

In use, it's unobtrusive and virtually silent save for intermittent voice announcements, although these can be muted. The housing is white, solidly built and sits on a supplied non-adjustable tabletop tripod. Thanks to the standard 3/8-inch female screw thread, the unit can also be mounted on any suitable tripod. It's so light that it's easily lifted with one hand. Simply place it in a spot with a clear view of the sky and it just gets on with the tasks you set, without fuss.

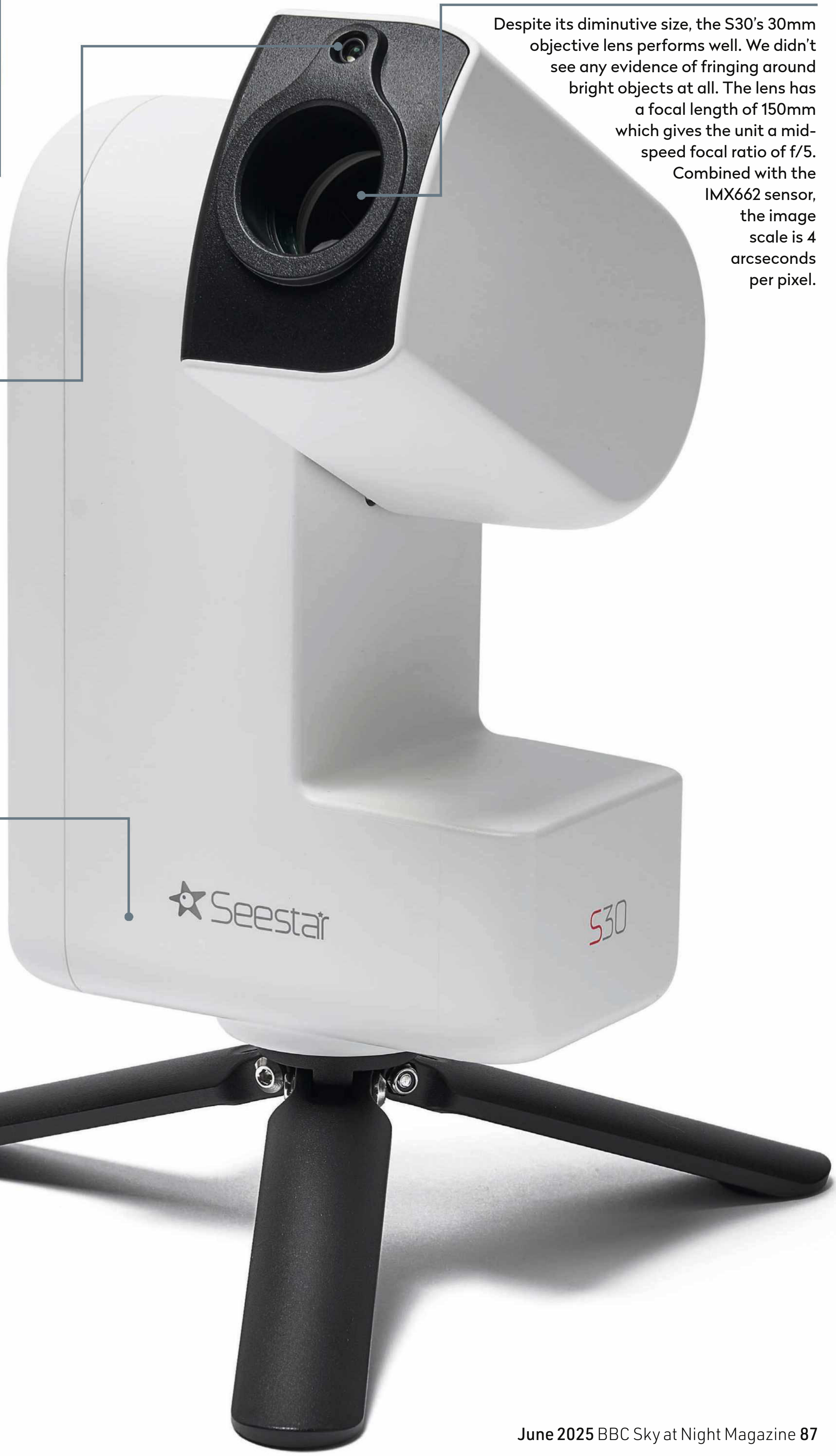
Control is via the same Seestar app used for the S50, so any app improvements or bug fixes are effectively applied to both devices. One example is the much-requested mosaic function. Announced almost at the same time as the S30, this provides the ability to image a larger area of sky in panes which are then stitched together. The S30 therefore has the long-awaited mosaic mode by default. Initially an altaz device, a recent app update towards the end of our review period also introduced an equatorial mode. This eliminates field-rotation effects and leads to fewer rejected long exposures.

We love live stacking

The S30's 30mm apochromatic triplet lens has a focal length of 150mm. Combined with the Sony IMX662 sensor, this produces an imaging field of 1.20° x 2.13°, which is large enough to cover most of the larger deep-sky objects (DSOs) and ideal should another bright comet appear. Imaging the Rosette Nebula, we were able to fit it in frame without resorting to the mosaic option. Watching this iconic 1.3°-diameter nebula slowly form on screen, despite light-polluted skies, ▶

Internal switchable filters

Internal filters can be selected through the app. A dual-band filter reduces the effects of bright moonlight and artificial light pollution – excellent for nebulae. Meanwhile, a UV/IR cut filter is used for clearer, sharper images. A dark field filter is automatically used for dark frame generation for noise reduction.



30mm apochromatic triplet telephoto lens

Despite its diminutive size, the S30's 30mm objective lens performs well. We didn't see any evidence of fringing around bright objects at all. The lens has a focal length of 150mm which gives the unit a mid-speed focal ratio of f/5. Combined with the IMX662 sensor, the image scale is 4 arcseconds per pixel.

Wide-angle scenery lens

The second, widefield lens is activated by selecting 'scenery mode' in the Seestar app and allows you to either centre your target before using the telephoto lens or capture widefield landscape photos. It also features an AI tracking mode, allowing you to automatically track moving objects.

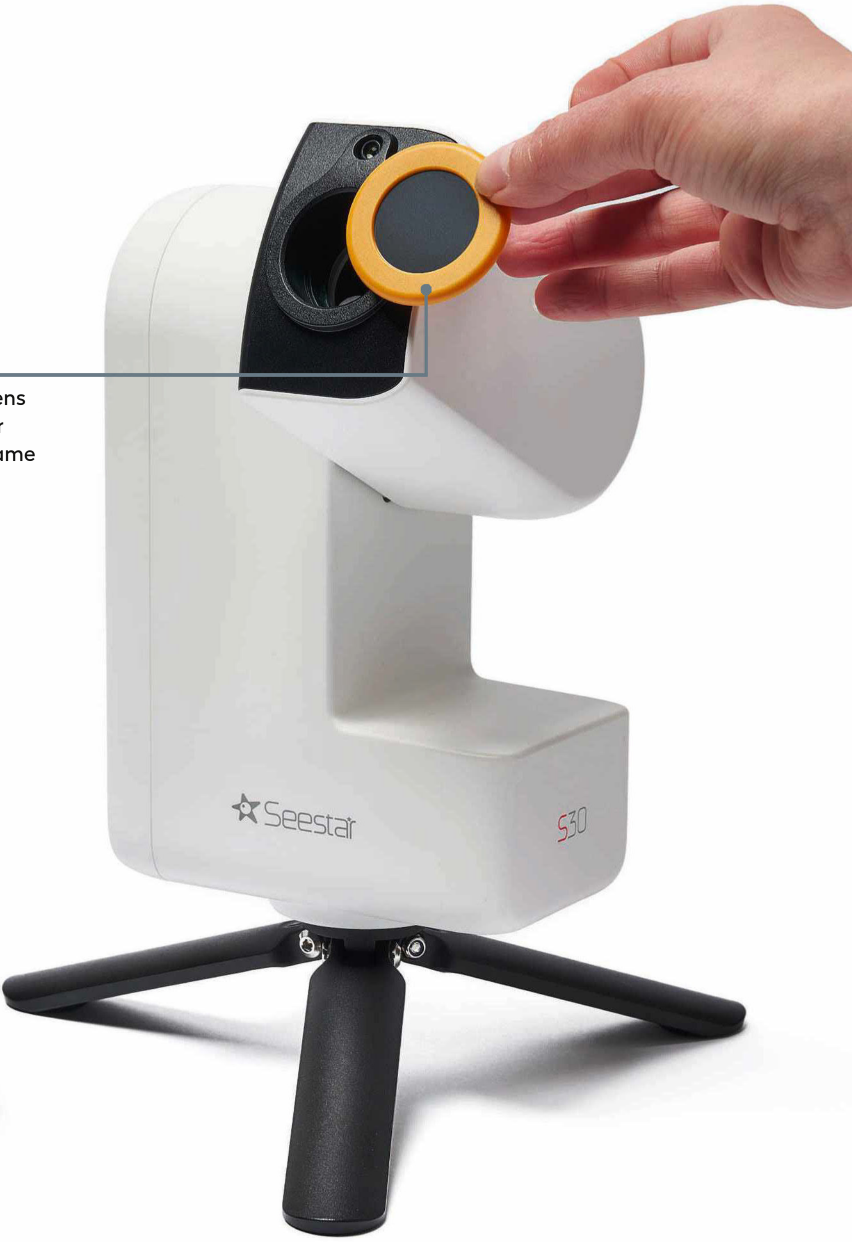
6,000mAh Battery

The S30 has an internal rechargeable 6,000mAh battery that can operate the unit for six hours of normal imaging. Switch on the anti-dew heater and the power will drain faster. However, plug an external USB-C battery into the S30's charging port and you can image all night long.

FIRST LIGHT

Magnetic solar filter

The magnetically attachable solar filter clicks over the 30mm lens to turn the S30 into a white-light solar telescope. You can either take single shots of the Sun through this filter or capture raw frame video which can later be registered and stacked through an external application such as AutoStakkert!

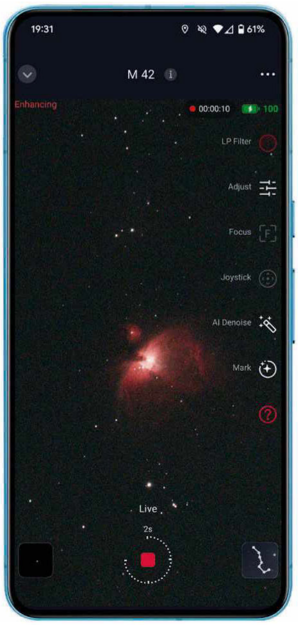

Seestar
S30

Ultra-portable all-season imaging

There's a lot to like about the ZWO Seestar S30, but one thing that really stands out is its portability. It's so light and small that it's easy to pop into a bag and carry to your preferred location for imaging. The Seestar control app works well with the device, giving you a powerful imaging solution that you can set up in minutes.

Astronomy imaging in the UK can be fraught with difficulty due to the weather, and telescopes often need to have an anti-dew heater fitted to avoid moisture ruining imaging sessions. With the S30, this is all built in; you simply need to turn it on in the app. If you can't get away from light pollution, there's again no need to carry around filters and filter wheels, because the S30 has a light-pollution filter option that can be turned on at the press of a button.

All in all, this amazingly portable device is optimally suited to extract the best from what can sometimes be rather challenging and changeable skies.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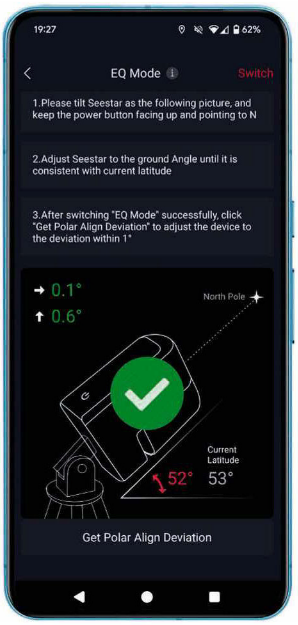

19:27

EQ Mode

1.Please tilt Seestar as the following picture, and keep the power button facing up and pointing to N

2.Adjust Seestar to the ground Angle until it is consistent with current latitude

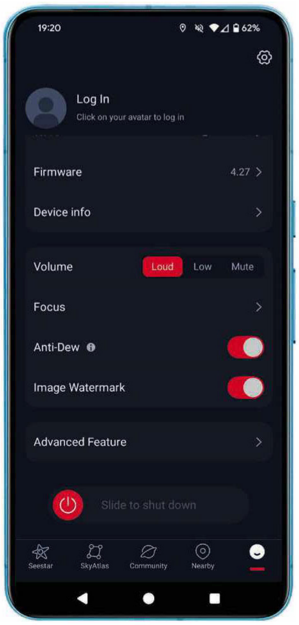
3.After switching "EQ Mode" successfully, click "Get Polar Align Deviation" to adjust the device to the deviation within 1°

→ 0.1°
↑ 0.6°

Current Latitude 53°

52°

62%
Switch
North Pole
Get Polar Align Deviation


19:20

Log In
Click on your avatar to log in

Firmware 4.27

Device info

Volume [✓ Loud] Low Mute

Focus

Anti-Dew ●

Image Watermark ●

Advanced Feature

62%
Slide to shut down
Seestar
SkyAtlas
Community
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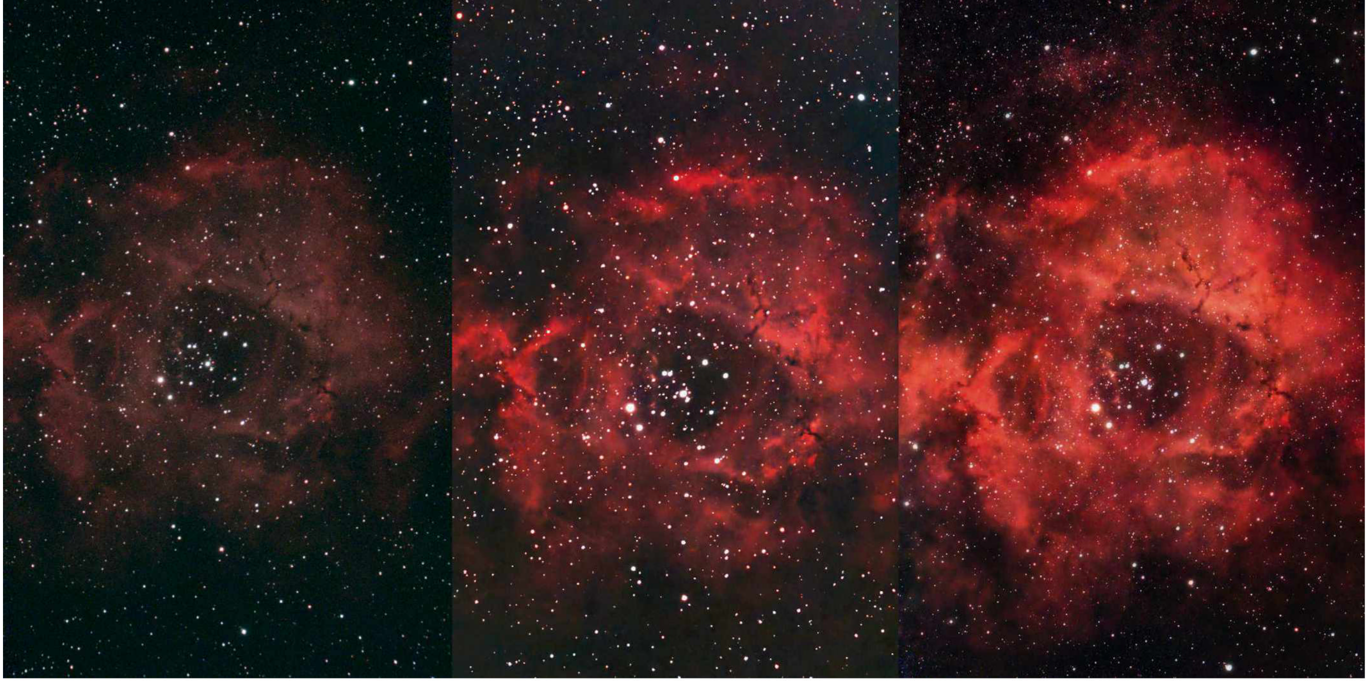


▲ **Watch your images take shape live on screen. This is our Rosette Nebula after letting the Seestar app's AI denoise function work its magic (centre) and after further processing externally with PixInsight (right)**

▲ **The S30 makes easy work of whole-disc Moon shots. This is processed from a 62-second 3,040-frame raw video, using AutoStakkert! and RegiStax**

▲ **The S30 comes with a dual-band filter for nebulae like M42, captured here in just 37 minutes of 10-second exposures**

▶ was rather magical. Mosaic mode expands the imaging frame to 2.39° x 4.25° but takes longer to complete. The unit also contains a second, wide-angle lens which is great for overview shots of the sky, although control options for this are currently limited. It's also good for widefield scenes or sunrise and sunset shots.

The control app includes an interactive virtual sky interface to select imaging targets. Once chosen, you simply 'Go-To' the object and start imaging. We found the S30's Go-To accuracy excellent for DSOs, but it can get a little confused with large, bright objects like the Sun (once the clip-on filter is installed) or a bright Moon. It uses plate solving to work out which stars it's pointing at for DSO navigation but is less reliable for these brighter objects. Here the wide-angle lens can be used to correct any mistakes and we found this to work particularly well. Once we had the Sun centred, we were able to sync on it then located Venus in the daytime sky without any issues. In terms of planets, the S30 doesn't have the focal length or aperture to do much.

Nighttime imaging is done through live stacking. Once the target has been identified and centred, the S30 takes exposures and stacks them on your phone. The individual exposures can be saved and, if you prefer, processed externally. The Seestar app also has a manual stacking option that allows you to select your data post-capture and then apply the app's own AI denoise function, which also produces excellent results.

While our time with the equatorial mode was limited, we found it very intuitive to set up. The S30 needs to be tilted for it to work, either using a wedge or adjustable tripod head. Initial testing suggests it's a valuable extension to the S30 and S50's capabilities.

Packed into a small yet mighty unit, we found the S30 to be a capable and impressively portable smart scope. For on-the-fly night-sky imaging, it's heaps of fun, inexpensive and produces great results.

VERDICT

Build & design	★★★★★
Ease of use	★★★★☆
Features	★★★★☆
Go-To/tracking accuracy	★★★★☆
Imaging quality	★★★★☆
OVERALL	★★★★☆

KIT TO ADD

1. Adjustable tripod

2. Photography wedge

3. External USB-C power pack

Our experts review the latest kit

FIRST LIGHT

RVO Horizon 8-inch f/4 imaging Newtonian

Want to photograph large nebulae and galaxies? This big, fast scope is no slouch

WORDS: JIM OWEN

VITAL STATS

- **Price** £499
- **Optics** Newtonian reflector, 8-inch (200mm) primary, 70mm secondary
- **Aperture** 200mm
- **Focal length** 800mm, f/4
- **Focuser** 2-inch dual-speed linear bearing Crayford focuser
- **Extras** Tube rings, dovetail bar, finderscope, 2-inch to 1.25-inch adaptor, 35mm extension tube, 12V battery pack
- **Weight** 8.5kg
- **Size** 700mm x 230mm
- **Supplier** Rother Valley Optics
- **Tel** 01909 774521
- **www.**rothervalleyoptics.co.uk

The term 'light bucket' is often used to describe large-aperture Newtonian telescopes due to their impressive photon-gathering capabilities. Rother Valley Optics's (RVO) 8-inch offering from its Horizon range is no exception. This Newtonian boasts a fast focal ratio of f/4, making it primarily designed for astrophotography, but you can also use it for visual observation. We were excited to try it out on some deep-sky targets, with a few clear nights on the horizon granting the perfect opportunity to put it through its imaging paces.

Opening the box, we were presented with a robust, white steel tube with attractive RVO labelling, mount rings and 335mm dovetail bar. The package includes a handy 8mm x 50mm multi-coated achromatic finderscope, as well as a 2-inch to 1.25-inch adaptor, 35mm extension tube and 12V battery power pack for the built-in tube-cooling fan.

We found the telescope required collimation before capturing test images. Given the fast focal ratio of this Newtonian reflector, precise alignment was crucial. After allowing the telescope to acclimatise to the outdoor temperature, we began collimating. The Horizon's large adjustment bolts for the primary mirror are easy to find and adjust, and the Phillips-head screws for the secondary mirror proved a user-friendly experience.

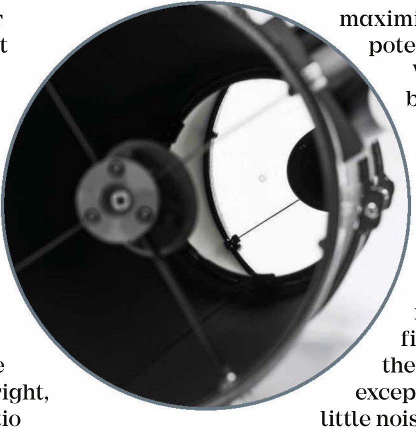
Most Newtonian telescopes suffer from light leaks behind the primary mirror and this one was no exception. Fortunately, simple fixes like covering the mirror end with a beanie hat or dark shower cap can effectively block stray light. We felt that baffles or flocking to prevent light bouncing around in the tube would be beneficial.

A bit of a beast

We did note that the Horizon's lack of a carry handle made it difficult to handle and mount; we recommend securing it firmly to your mount before attaching imaging equipment. A sturdy mount is essential for this large tube, as its size and weight make it vulnerable to wind.

We tested the scope initially without a coma corrector, revealing noticeable coma that distorted the image – not surprising, given the focal ratio. To ▶

Light-grabbing powers



The RVO Horizon 8-inch f/4 imaging Newtonian is an excellent option for astrophotography, thanks to its fast f/4 focal ratio. This feature offers several key advantages, including shorter exposure times for capturing deep-sky objects more efficiently – always a plus when skies are temperamental. The compact design enhances its portability, making it possible to consider taking to dark-sky sites.

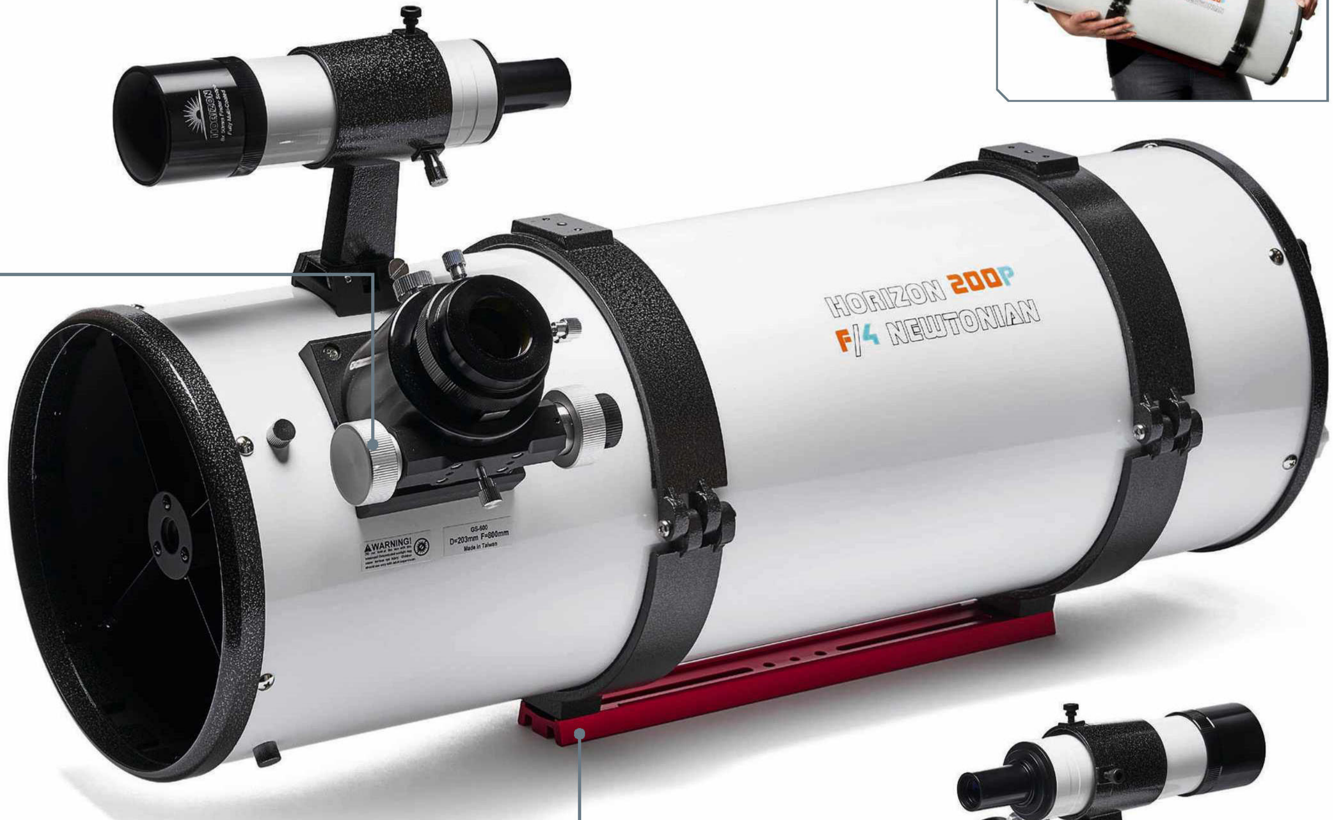
We found that the wide field of view provided by the Horizon's fast optics is perfect for capturing large nebulae and galaxies, delivering bright, high-contrast images. The focal ratio worked well with a CMOS camera, maximising the telescope's imaging potential.

We were also able to take beautiful narrowband images, despite its fast focal ratio – although it's crucial to use compatible filters, as filters not designed for such fast optical systems may introduce unwanted artefacts or colour distortions. Using our own narrowband SII, Ha and OIII filters we had no issues, and the Ha data in particular was exceptionally clear with very little noise present.

ALL PHOTOS: @THESHED/PHOTOSTUDIO

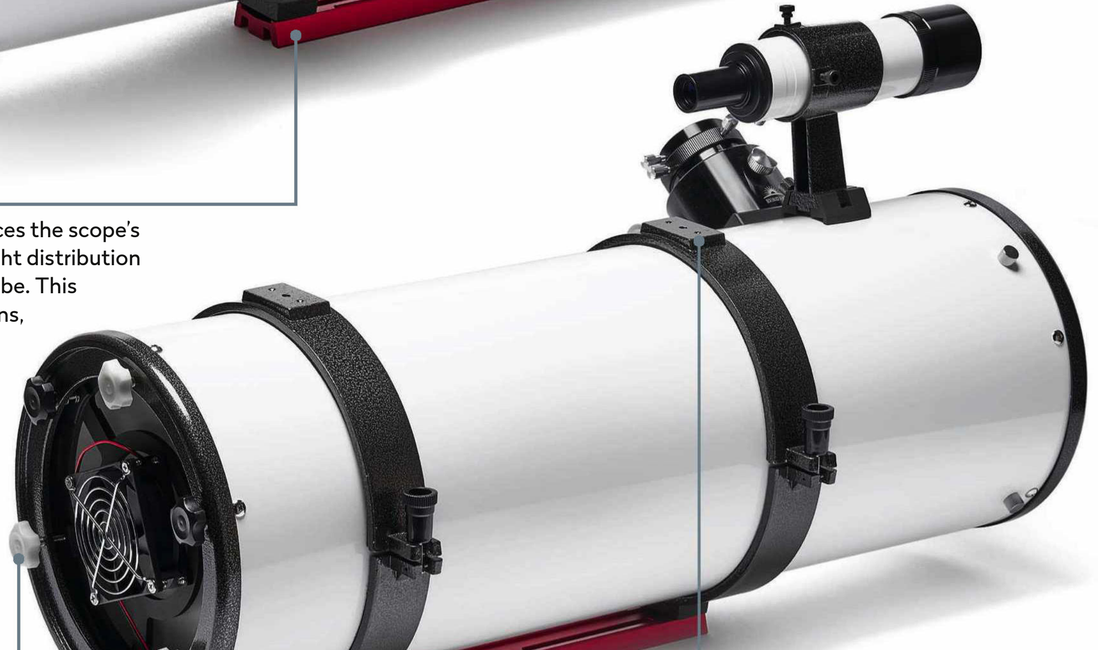
Sturdy focuser

The telescope's Crayford focuser offers precision and stability, with a dual-speed mechanism including a fine focuser. It can also accommodate an electronic automatic focuser, allowing motorised control. This design enhances versatility for visual observations and imaging, and provides an ideal platform for precise focusing of heavier eyepieces or cameras.



Large dovetail

The 335mm dovetail bar enhances the scope's stability by providing good weight distribution and support for the extended tube. This longer dovetail reduces vibrations, improves rigidity and allows for more precise balancing on various mounts, resulting in more stable observations and imaging sessions.



Large collimation bolts

The Newtonian's large collimation bolts offer easier adjustments and precise control during an often fiddly process. They enhance stability during transport and maintain optical alignment, contributing to improved image quality and a better experience for users. It's a design that's beneficial for beginners and experienced astronomers alike.

Accessory mounting

There are two convenient sets of threaded holes for attaching accessories such as guidescopes or finders. These enhance the system's versatility and allow customisation that improves the balance and stability, eliminating the need for makeshift solutions.

KIT TO ADD

1. Coma corrector
2. Guide kit
3. Collimator

▶ rectify this, we incorporated our own coma-reducing corrector into the imaging train, which did the trick.

On the first clear night, we used a Sony IMX571 colour CMOS sensor, which measures approximately 23.5mm by 15.7mm. Paired with the coma corrector, this reduced the focal length to 770mm and a faster focal ratio of f/3.85. This provided a field of view that framed the Double Cluster, NGC 869 and NGC 884, nicely. The individual frames provided a stunning view of the stars in the cluster and were crisp and sharp right up to the edges. In the same session, we slewed the mount to M81 and M82, both galaxies again fitting into the field of view and benefitting from the light-gathering ability of this scope.

The camera and coma corrector were firmly mounted on the focuser with no flex evident, held in place by the focus-retaining screw. The setup remained stable during most of the imaging sessions, requiring only a couple of focus adjustments when changing filters. Focus stability can be an issue during long imaging sessions, especially in cold conditions; in our first session, we experienced focus drift after about 75 minutes.

The following night, we were blessed with another clear sky, using the opportunity to image Melotte 15, IC 1805, in the centre of the Heart Nebula with a monochrome camera and narrowband Ha, SII and OIII filters, unveiling stunning details.

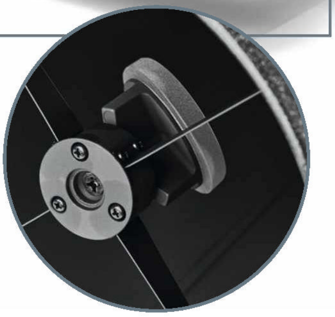
Overall, we enjoyed using the RVO Horizon 8-inch f/4 imaging Newtonian. It's an excellent choice for astrophotographers looking to capture high-quality images. The telescope provides a solid foundation and, when paired with the right accessories, creates a powerful setup capable of producing stunning deep-sky photographs. With its fast f/4 focal ratio and generous 8-inch aperture, it offers a winning combination of light-gathering ability and wide field of view, making it well suited for a variety of deep-sky targets.

VERDICT

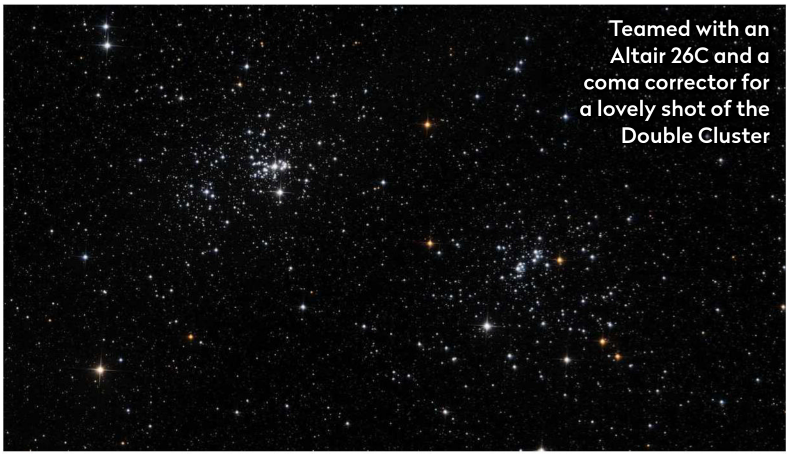
Build & design	★★★★☆
Ease of use	★★★★☆
Features	★★★★☆
Imaging quality	★★★★☆
Optics	★★★★☆
OVERALL	★★★★☆

@THESHED/PHOTOSTUDIO, JIM OWEN X 3

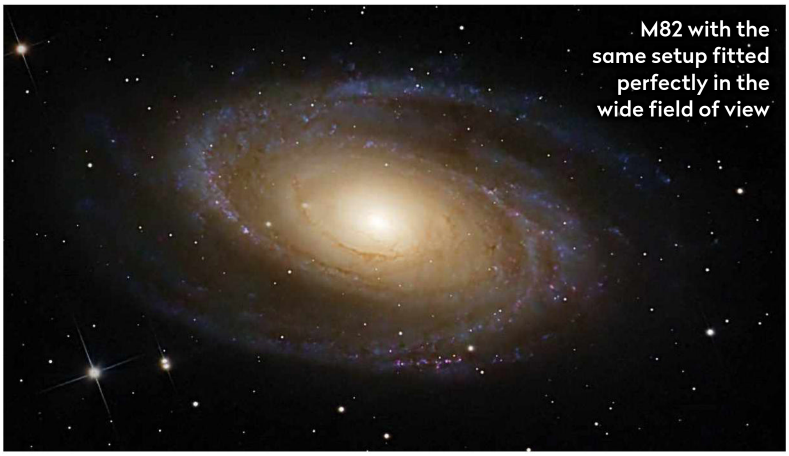
Oversized secondary mirror



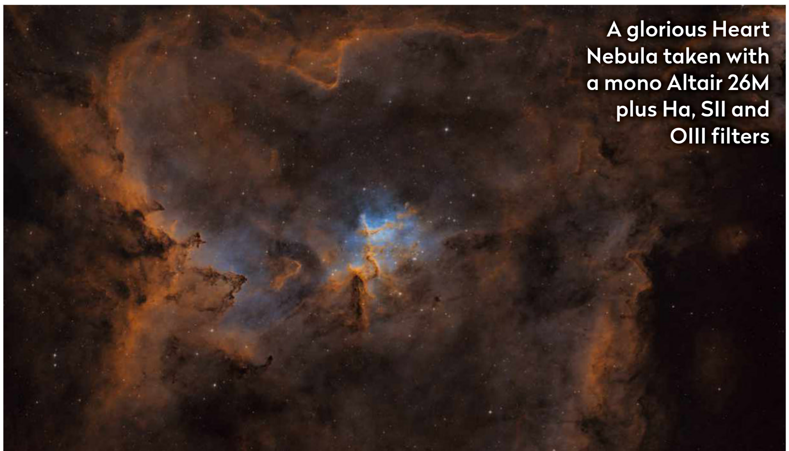
The Horizon's 70mm oversized secondary mirror provides full illumination for APS-C format cameras and approximately 90 per cent illumination for full-frame astronomy or DSLR cameras, allowing flexibility within your imaging setup. Nevertheless, we'd always recommend taking flat frames to remove or reduce any vignetting.



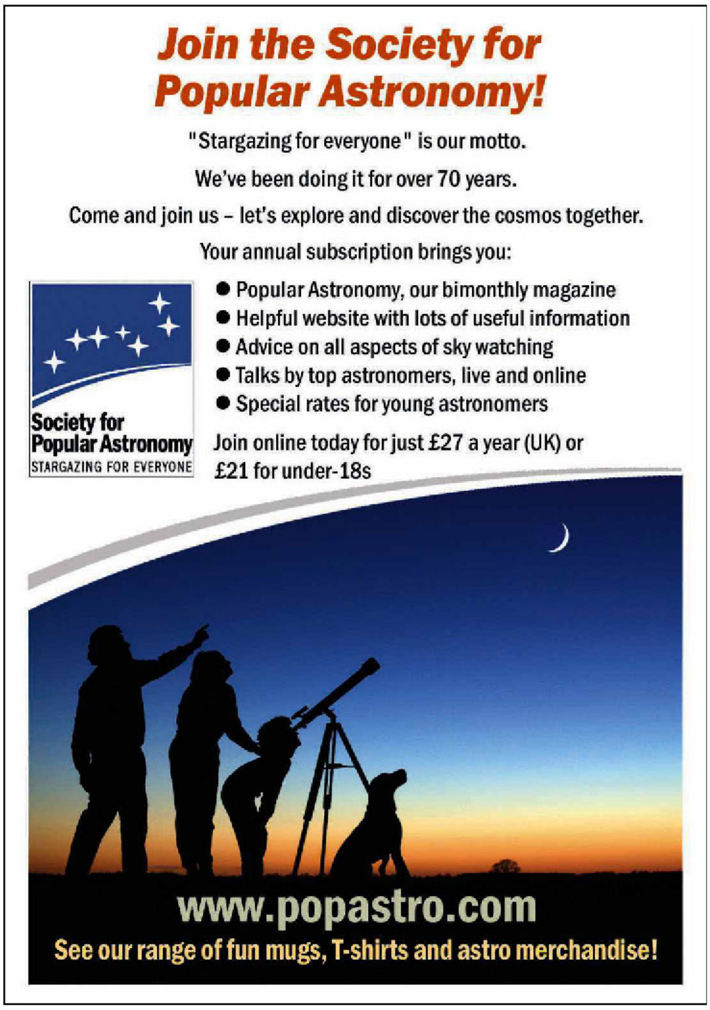
Teamed with an Altair 26C and a coma corrector for a lovely shot of the Double Cluster



M82 with the same setup fitted perfectly in the wide field of view



A glorious Heart Nebula taken with a mono Altair 26M plus Ha, SII and OIII filters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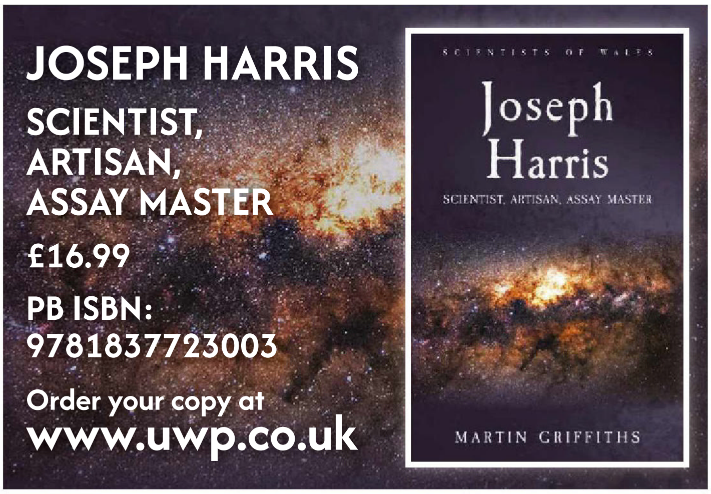
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Charlotte Daniels rounds up the latest astronomical accessories

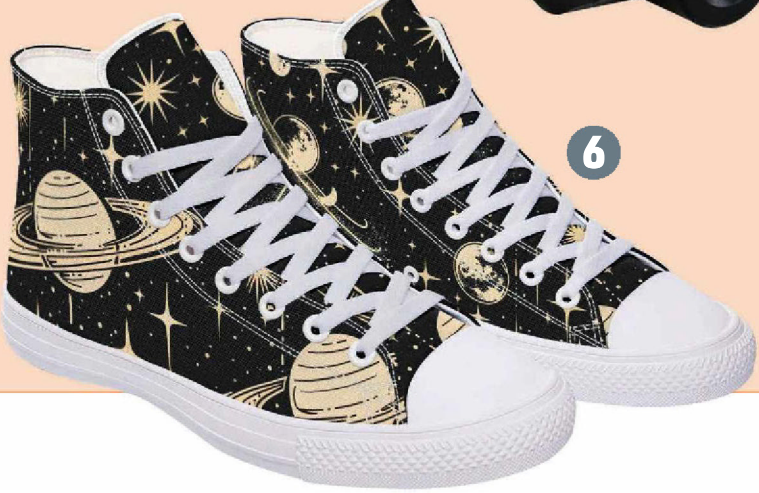
GEAR

ECLIPSMART
SOLAR SAFE
1

2
ToupTek
ToupTek Astro
TEMP HBX
TYPE-C

4
STARFIELD

CELESTRON
5



1 Celestron EclipSmart 10x42 solar binoculars

Price £94 • **Supplier** Harrison Telescopes **www.harrisontelescopes.co.uk**

Summer's here and the Sun is at solar maximum. Enjoy views of sunspots (and future eclipses) through these specialist binoculars. Featuring solar-safe filters and multi-coated optics, they provide 10x magnification and allow the full solar disc to be displayed.

2 ToupTek astro automatic focuser

Price £170 • **Supplier** Specialist Cameras International • **www.specialistcameras.co.uk**

Auto-focusers are a handy astrophotography tool offering both precise focusing power and the ability to simplify the imaging set-up process. This model features an onboard temperature sensor and is compatible with several telescope manufacturers, including certain Sky-Watcher, Askar and TS models.

3 Altair electronic filter wheel

Price £299 • **Supplier** Altair Astro **www.altairastro.com**

Electronic filter wheels allow you to deftly switch between colour or narrowband filters without dismantling your kit mid-session. This one is only 20mm thick, takes up to seven 2-inch filters and arrives with a set of adaptors and spacers that make it compatible with most astronomy cameras.

4 Starfield constellation baseball cap

Price £19.99 • **Supplier** Infinity Collectables **https://infinitycollectables.com**

Did we mention summer is here? This baseball cap features a NASA-esque mission patch and should help protect your head during those rare sunny days. There's an adjustable strap at the back.

5 Celestron night vision red headlamp

Price £19.99 • **Supplier** The Widescreen Centre **www.widescreen-centre.co.uk**

The nights might not be fully dark this month, but your eyes still need a helping hand to survey summer targets! This red-light headlamp with adjustable strap supports dark adaption and keeps your hands free to swap eyepieces and filters or slew between objects.

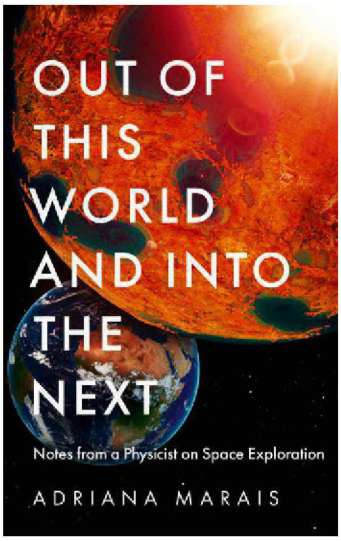
6 Rings of Saturn high-top shoes

Price £85 • **Supplier** Rogue + Wolf **www.rogueandwolf.com**

We think these canvas shoes are rather eye-catching! Adorned with celestial imagery, they'd be great for wearing to your next astronomy meet. Made from 100 per cent vegan materials, they're available in men's and women's sizes, and with black or white soles.

New astronomy and space titles reviewed

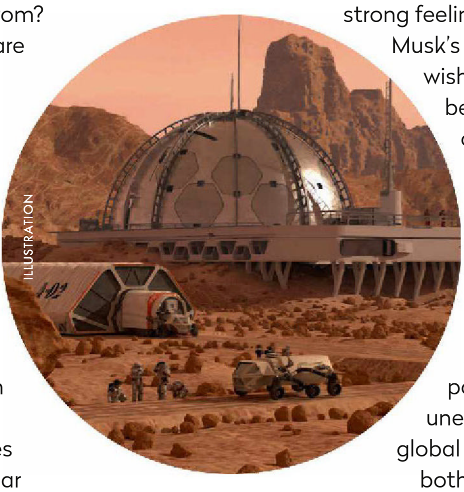
BOOKS


OUT OF THIS WORLD AND INTO THE NEXT
Notes from a Physicist on Space Exploration
ADRIANA MARAIS

Out of this World and Into the Next

Adriana Marais
Profile Books
£18.99 ● HB

Where do we come from? Who are we? Where are we going? These are fundamental and profound questions that encompass the whole of human existence. Adriana Marais takes us back to the beginning of the Universe, from the Big Bang through the formation of the first stars and galaxies to the birth of our Solar System and the creation of Earth. She then discusses how life may have emerged here and evolved to produce the complex web we see today, including us. It carries us through our migrations, adaptations, innovations and explorations, to our current search for life beyond Earth.



The author pictures humanity founding a utopian settlement on the Red Planet

The book then details the state of our planet today, the inequalities in our distribution of resources and the damage we continue to wreak on our environment. All this is well-written and thought-provoking. Marais then looks forwards to our future and envisions us inhabiting Mars rather than fixing the problems here on Earth. She pictures an ideal egalitarian Martian society, sharing resources and trading back and forth with Earth.

Marais is an award-winning quantum astrobiologist and theoretical physicist. She was one of 100 astronauts chosen for the Mars One project and is the founder of Proudly Human (Off-World), so she speaks from experience. The book has a wide reach, covering many complex topics, from quantum photosynthesis to terraforming, nuclear fusion reactors to asteroid mining. It is fast-paced and quite wordy, so you need to keep up.

Recent events have overtaken the writing. It was written before Elon Musk became involved in American politics and so Musk is presented solely as the head of SpaceX. Consequently, readers with strong feelings either way on Musk's political foray may wish the author had been afforded the opportunity to share her thoughts on this development.

I found the analysis of our world today, with many jaw-dropping statistics about pollution and the unequal distribution of global resources, to be both sobering and fascinating. The segment imagining a day on a utopian Mars settlement was disappointingly mundane, though probably quite accurate. This is an intelligently written book that left me with more questions than answers, which is perhaps no bad thing. ★★★★☆

***Jenny Winder** is a science writer and broadcaster*

3000AD/GETTY, AUTHOR PHOTO: KAT GRUDKO

Interview with the author

Adriana Marais

How realistic is putting humans on Mars?

Imagine what it was like for our ancestors setting out to seek new lands. Travelling beyond Earth, we have more detailed knowledge of what to expect than they did. Permanent lunar bases are planned for this decade as a gateway to Mars and beyond. If SpaceX doesn't get to Mars first, China is planning to land crew in 2033, while the UAE is planning a Martian city by 2117.

How can we ensure that humanity settles on other worlds responsibly?

We all have front-row seats for our expansion beyond Earth. Lunar bases are planned by China and the US and their partners this decade. Lunar resource extraction is also on the cards. Shortages fuelled by conflict, sanctions, extreme weather, consumerist culture and short-comings in waste management could make it cost-efficient to deliver resources from the Moon to Earth. Will regulation keep up? Mars may be far enough away to provide a chance for us to reimagine ourselves.

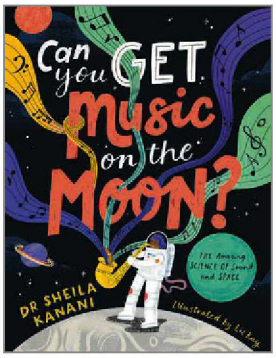
Could we reach a planet beyond our Solar System?

Warmed in the light of our star, we have evolved, explored and innovated, and now are on the brink of creating our own suns. Hopes are high for the availability of fusion power technology in as little as a few years' time. Fusion propulsion systems could provide efficient, sustained acceleration without the need for a large fuel supply. But we have much to learn about our Solar System, and ourselves, before we get that far!

***Adriana Marais** is a physicist and director of the Foundation for Space Development Africa*

Can You Get Music on the Moon?

Sheila Kanani and Liz Kay
Puffin
£14.99 ● HB


Can you GET music on the MOON?
The amazing science of sound and space
DR SHEILA KANANI
Illustrated by Liz Kay

This is the latest in a series from the author (Sheila Kanani) and illustrator (Liz Kay) behind *Can You Get Rainbows in Space?* and *Can You Get Jellyfish in Space?* With bright colours, energetic drawings and informal descriptions, it's likely to be as appealing to children as the previous books.

Although the title raises the possibility of lunar music, we don't reach the Moon until towards the end of the book. First, we learn about the physics behind the generation and transmission of sound waves, and the different ways those waves travel by means of reflection, refraction and diffraction. The book explores topics relating to sounds in the natural world and how species produce and detect sound in a variety of ways and for different purposes.

Fun facts abound: owls' ears are misaligned, allowing them to pinpoint more precisely the location of their prey; bats' use of echolocation is so accurate they can detect individual insects; and we humans can still hear under water even when we block our ears, because our skulls are able to transmit sound waves.

We learn that movements in Earth itself generate sound waves that can be used to forecast earthquakes and provide information on Earth's geological makeup. The Sun isn't the only star to vibrate and quake; it's thought all stars do so through the large-scale movements of gas within their interiors. Sound waves can't propagate through the vacuum of space, but electromagnetic radio waves produced by astronomical objects can be converted to audio equivalents, to allow them to be perceived in a more direct way than numbers or graphs.

The book is perhaps too keen to include radio waves in its characterisation of sound, when the two phenomena are quite different, but this allows it to include interesting explanations of emissions from black holes and the cosmic microwave background. It also discusses the most intriguing recordings of sounds that we will never hear: the golden records on board the two Voyager spacecraft, which have now travelled beyond the Solar System. These records contain a mixture of natural and artificial sounds, in the hope that alien intelligence will one day encounter them and learn something about our planet and civilisation.

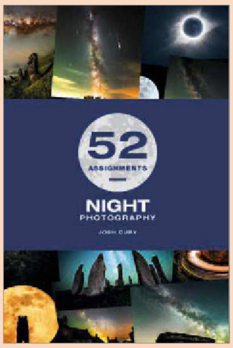
This book is packed full of facts that will pique young readers' curiosity, engaging them in the physics of our planet and the Universe beyond.
★★★★☆

***Pippa Goldschmidt** is an astronomy writer*

52 Assignments: Night Photography

ASTRO IMAGING

Josh Dury
Ammonite Press
£12.99 ● HB



52 Assignments is unique because, rather than presenting reams of difficult-to-digest technical detail, it gives a series of weekly practical challenges that build the photographer's skills and confidence.

The introduction covers night photography basics, equipment and camera terminology. Then follows a series of tasks to be completed every week, starting simply with things like capturing the Moon up close or within a landscape, building to more complex projects like creating a panorama or composite. It covers every night-sky subject: noctilucent clouds, aurorae, eclipses, the Milky Way and more. There are even assignments that introduce the rule of thirds and leading lines into your photography. Each assignment page manages to condense lots of technical information, tips and tricks into a short section of text.

There is a helpful key with symbols for things like technique, weather, journal and equipment, and each assignment page has the relevant symbols, so you know which skills are being tested. We really loved that the first three assignments are all about experimenting with different camera settings and analysing your own results. This is helpful for people who are just starting out in night-sky photography, and readers are encouraged to keep a journal of results, which is essential when getting to know your own equipment.

As the assignments progress, there are some that are more challenging – like number 30 which covers imaging galaxies and nebulae – but each one is explained in such a clear and concise way that everyone will feel confident trying it.

The print quality is a letdown in places. There are images where stars in darker regions of sky are missing and foreground illumination and colour vibrancy have been lost when compared to the digital version I was able to read for this review, one example being an image of the Milky Way core above a poppy field. However, this does not detract from the purpose of the book.

It's refreshing to see such a practical approach to night photography, where the reader learns by actually taking photos rather than just reading about it. It is a book that every photographer can learn from and enjoy. Photographers of all experience levels will get enjoyment from this unique, practically focused night photography guide. ★★★★☆

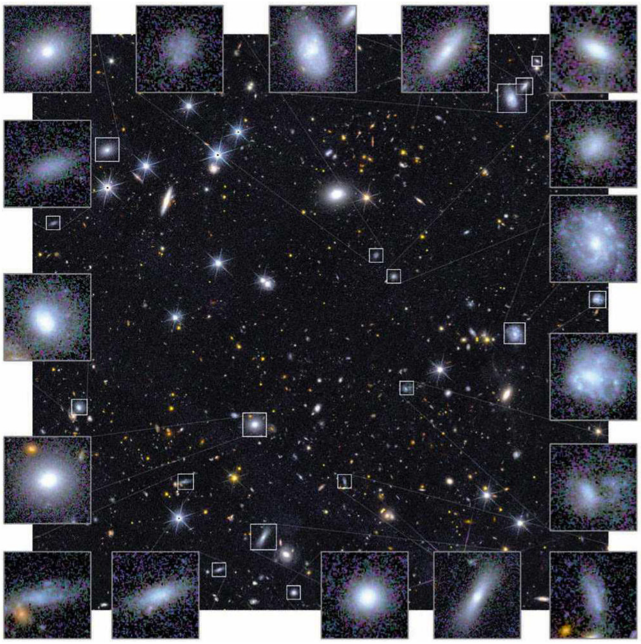
***Mary McIntyre** is an astrophotography educator*

Anita Chandran talks to Professor Francine Marleau

Q&A WITH A DWARF GALAXY HUNTER

The Euclid space telescope has only just begun its six-year-long mission to map the night sky, but it's already revealed a treasure trove of new galaxies

What did your team discover?
We discovered around 2,600 low-mass, very low-surface-brightness, faint galaxies from data released by the Euclid space mission. These are historically very hard to find because they're so small and faint, but they're the most numerous galaxies in the Universe. Our dataset was from only 0.4 per cent of the total survey we will eventually get from Euclid, so this was an initial survey of a much larger dataset.



▲ **Researchers have identified more than 2,600 very faint dwarf galaxy candidates in Euclid's first data release**

What is Euclid?
Euclid is a space mission that ESA launched in 2023. Its goal is to take images and spectral data in the optical and infrared of around one third of the sky. It does that with fantastic sharpness, because the telescope is in space and responsive to very low brightnesses. One of Euclid's goals is to map the Universe's structure and probe the nature of dark matter and dark energy on the cosmic scale. Because it can see such a wide area, it can give us an idea of how astronomical objects are clustered on a cosmic scale. But it also includes other scientific investigations, like this project, which was to look at the population of what we call dwarf galaxies.

What is a dwarf galaxy?
Dwarf galaxies are small, low-mass galaxies. This means that in terms of the stars and dark matter they contain, they're at the lower end of the mass spectrum. We consider these small galaxies to be dwarf galaxies when their stellar mass is around a billion times the mass of our Sun or less. Usually, these galaxies orbit larger galaxies, like the Magellanic Clouds orbit the Milky Way.

Francine Marleau is an associate professor at the University of Innsbruck, Austria, working on extragalactic astronomy, including galaxy formation and evolution

Are you able to confirm that what you've found are dwarf galaxies?
This is difficult, because we're working essentially with an image, and we don't know how far away these objects are. In cases like this, it's hard to work out their mass. What we found is that some of these objects had a spectrum – a light-based fingerprint – from which you can work out how distant they are. From that, you can work out their mass, and we found that they matched the masses we expected for dwarf galaxies.

What have you learned about dwarf galaxies from your discovery?
This is just a first glimpse, but we've found within the discovered galaxies a subgroup that have blue central regions, sometimes with quite a strange structure. This is a sign of star formation. From this, we think we're witnessing a fascinating transitional period in a galaxy's life. Some of the other dwarfs have a central – or nuclear – star cluster, which are some of the densest stellar objects in the Universe and can sometimes also host a central massive black hole.

We think these may be in the process of forming star clusters. This is one of the important things Euclid enables. When you see a distant dwarf galaxy from a ground-based telescope, you just see a fuzzy object. But from Euclid, you can see the substructures inside these galaxies.

How do they differ from bigger galaxies, those that are more than a billion times the Sun's mass?
There's no general answer for all galaxies, but one thing we think is important is the dark matter content of the galaxies relative to their stars. We find that dwarf galaxies have the highest ratio. Another interesting feature of dwarf galaxies is the ratio of stars they form per year compared to their total mass. Dwarf galaxies have the highest star-formation rate per unit mass of all galaxy types in the Universe.

What's next for your research team?
As we've only looked at part of the data, our next goal is to do a full analysis of the data that's been released by Euclid. We also hope to optimise our detection technique and follow up these dwarf galaxies with ground-based spectroscopic observations, using telescopes like the European Southern Observatory's Very Large Telescope.

ESA/EUCLID/EUCLID CONSORTIUM/NASA/FRANCINE MARLEAU ET AL 2025

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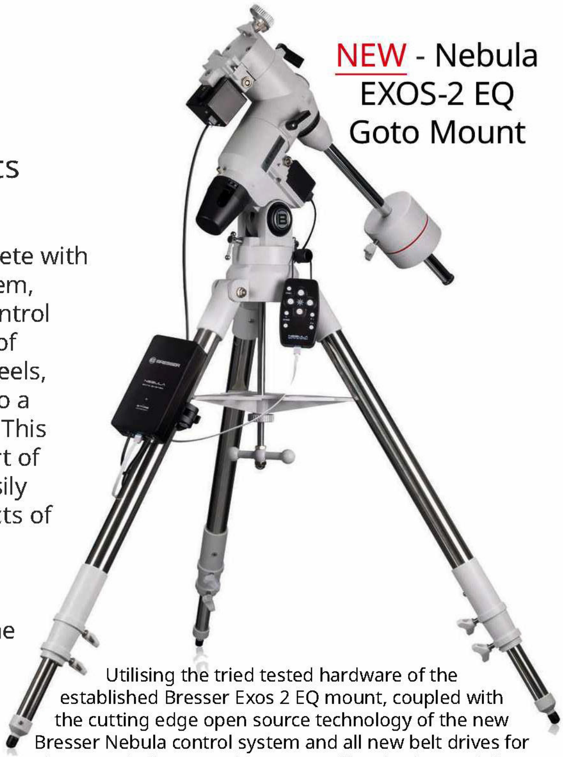

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Enjoy Mercury in the evening sky and explore often-overlooked Norma in the southern Milky Way

When to use this chart

1 Jun 00:00 AEST (31 May, 14:00 UT)
15 Jun 23:00 AEST (13:00 UT)
30 Jun 22:00 AEST (12:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

JUNE HIGHLIGHTS

June and July see Mercury making its best evening return for 2025. After emerging from behind the Sun in early June as a fully lit 5-arcsecond disc, it's visible low in the twilight by mid-June, showing a phase like a gibbous Moon. At month's end, the disc has grown to 7.5 arcseconds with a quarter Moon shape. During July, Mercury heads towards inferior conjunction as it grows to around 11 arcseconds, looking like a fingernail sliver as it is returns to the twilight glow.

STARS AND CONSTELLATIONS

Scorpius returns to early evenings, sitting on its tail above the eastern horizon. Above it is faint Libra, the Scales. Both constellations are part of the zodiac, meaning 'circle of animals'. So where do scales fit in? In ancient times, Libra was part of Scorpius. The names of its two brightest stars, Zubenelgenubi and Zubeneschamali, betray their origins, translating to 'southern claw' and 'northern claw'. Today the scales are often depicted being carried by Lady Justice.

THE PLANETS

Mercury returns to the evening sky mid-June, reaching maximum altitude in early July. Mars is now low in the northwest evening sky, departing around 22:00. From 14th to 20th, the Red Planet is within 2° of the blue star Regulus, showing nice colour contrast. Saturn and Neptune rise around 01:00 mid-month, with Venus remaining a prominent beacon close to the eastern horizon from around 04:00. In early June, Uranus rises quickly out of the dawn glare, closing the month 5° below Venus.

DEEP-SKY OBJECTS

This month, a visit to the lesser-known constellation of Norma. A prominent bright knot 5° across is easily visible, which includes the impressive open star cluster NGC 6067 (RA 16h 13.2m, dec. –54° 13'). Just 0.4° north of the fifth-magnitude yellow star Kappa Normae, this mag. +5.6 0.2°-diameter rich cluster shows a couple of dozen bright stars, surrounded by around 100 fainter members displaying numerous doubles and curved lines of stars. In fact, its brightest member is a double, V340 Normae, with mag. +8.6 and +9.1 components, separated by 9 arcseconds.

Returning to Kappa, move 3.2° west to the striking double star Dunlop 193 (RA 15h 51.1m, dec. –55° 03'). The double has a bright (mag. +5.8) white primary with a fainter (mag. +9.0) orange companion, a comfortable 18 arcseconds apart.

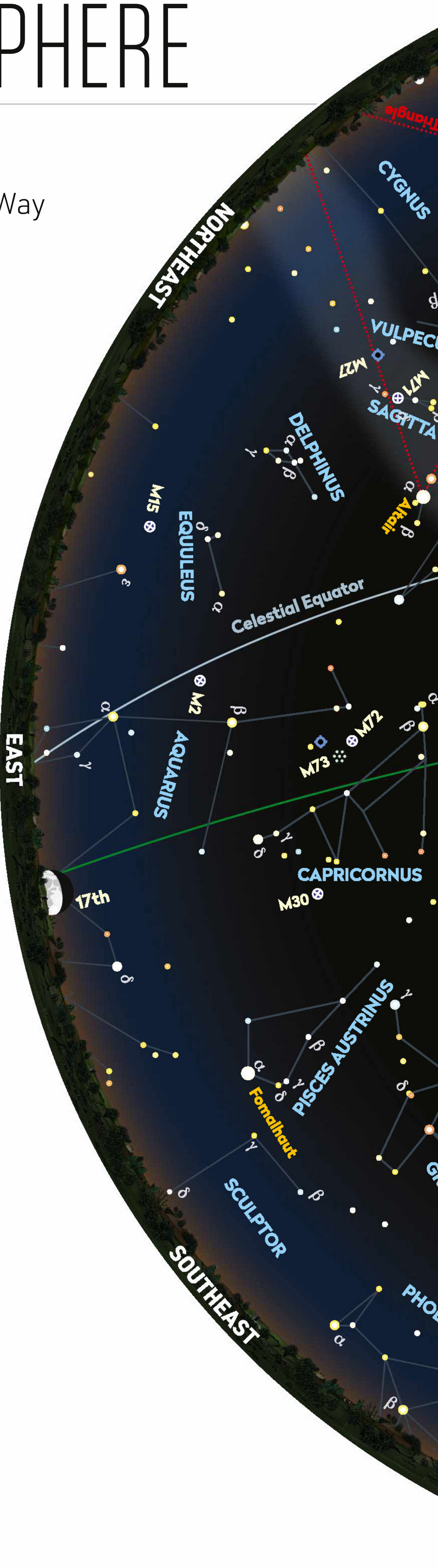
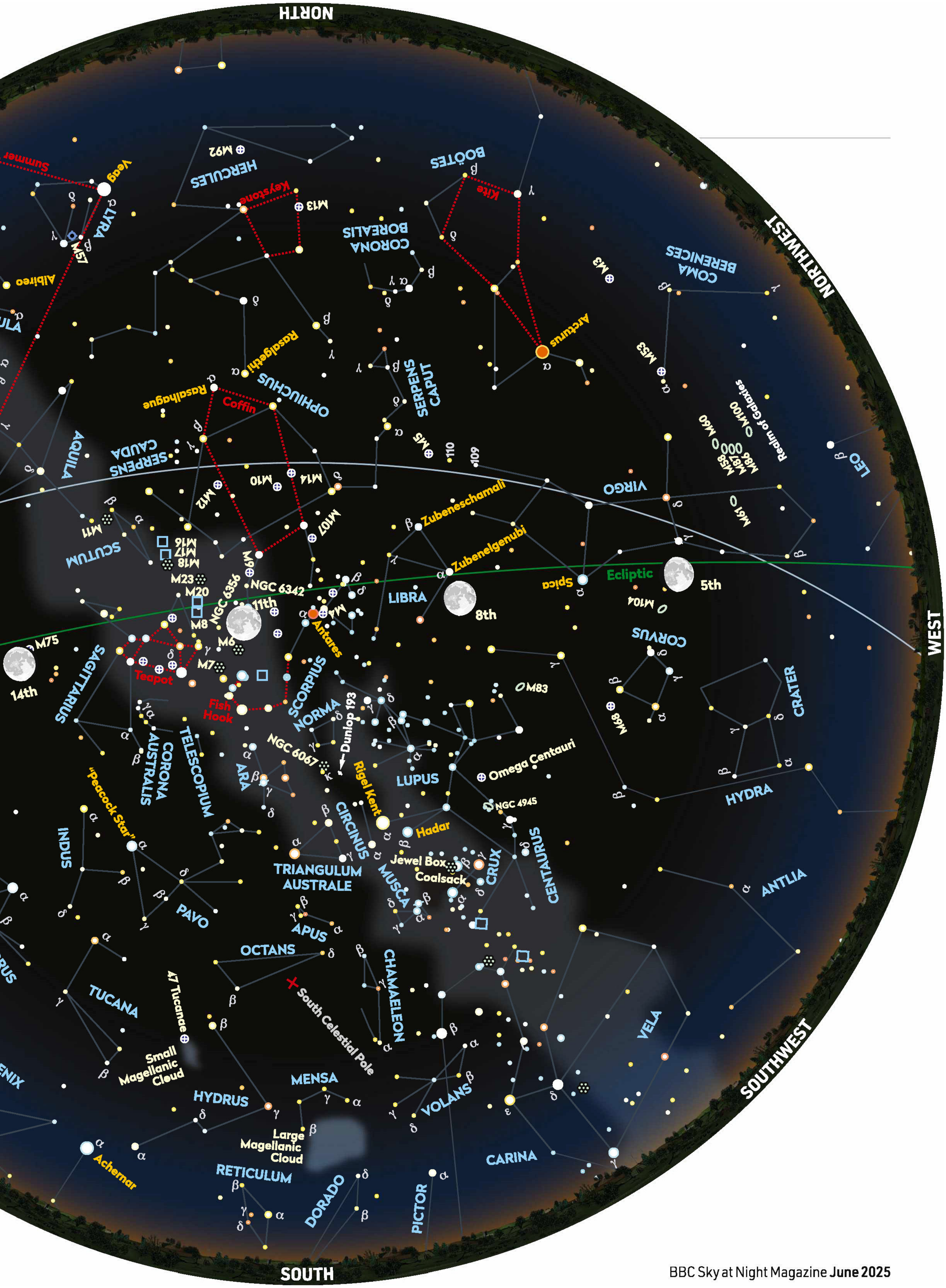


Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- ● MAG. 0 & BRIGHTER
- ● MAG. +1
- • MAG. +2
- • MAG. +3
- · MAG. +4 & FAINTER

CHART: PETE LAWRENCE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WEST
SOUTHWEST
SOUTH
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BOÖTES
Kite
M3
COMA BERENICES
Arcturus
Rasalgethi
Rasalhague
Coffin
OPHIUCHUS
SERPENS CAPUT
M53
M5
SERPENS CAUDA
AQUILA
M12
M10
M14
110
109
Realm of Galaxies
M100
M60
M58
M87
M86
M61
LEO
VIRGO
Zubeneschamali
Zubenelgenubi
M107
M11
SCUTUM
M16
M17
M18
M23
M20
M8
M9
NGC 6356
NGC 6342
11th
M19
M4
Antares
LIBRA
8th
Spica
Ecliptic
5th
M104
CORVUS
M75
14th
SAGITTARIUS
Teapot
M6
M7
Fish Hook
SCORPIUS
NORMA
Dunlop 193
M83
M68
CRATER
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